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FIRES: Fire Information Retrieval and Evaluation System—a Program for Fire Danger Rating Analysis

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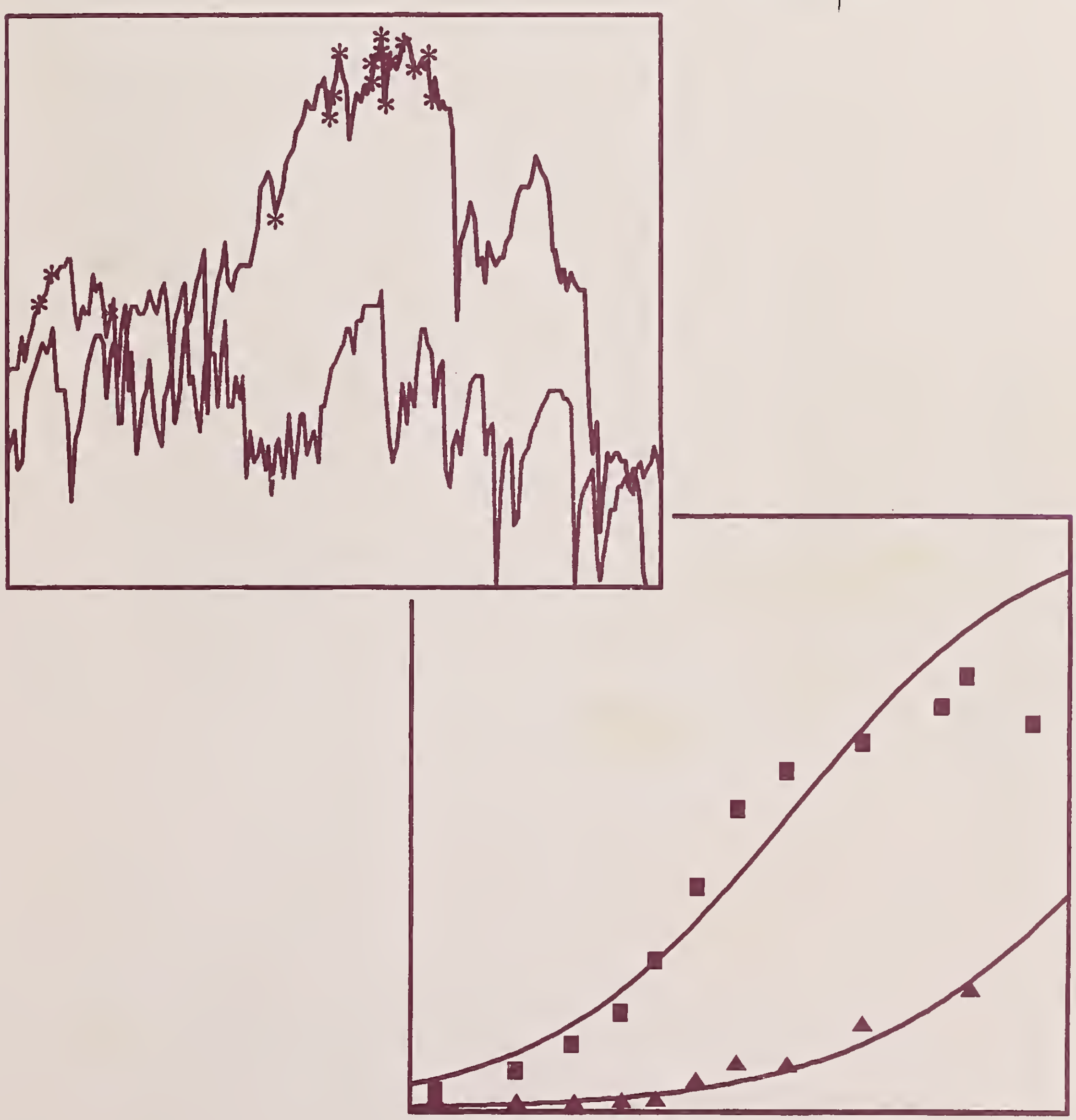

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Research Summary

A computer program, FIRES: Fire Information Retrieval and Evaluation System, provides methods for evaluating the performance of fire danger rating indexes. Although examples in the paper are for the U.S. National Fire Danger Rating System (NFDRS), indexes from any fire danger rating system can be examined. The relationship between fire danger indexes and historical fire occurrence and size is examined through logistic regression and percentiles. Historical seasonal trends of fire danger and fire occurrence can be plotted and compared. Methods for defining critical levels of fire danger are provided. The paper includes a review of NFDRS philosophy and application, a description of input and output, and a summary of fire danger rating programs and data bases and their relationship to FIRES.

Acknowledgments

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Introduction

Fire danger rating systems have been in use in the United States since 1934 (Gisborn 1942). A national system was introduced in 1964 (U.S. Forest Service 1964). The current version of the National Fire Danger Rating System (NFDRS) was implemented in 1978 (Deeming and others 1977), with optional revisions being added in 1988 (Burgan 1988). NFDRS is widely used by land management agencies in the United States for fire management applications such as prevention and presuppression planning. When an index reaches a designated level, for example, management actions such as forest closure and additional prevention measures might go into place.

Despite widespread use of NFDRS, confusion persists about proper interpretation and application of fire danger rating. Over 50 years after introduction of the first system, an NFDRS Improvement Workshop report (USDA Forest Service 1985) included statements that "No consensus exists on the purpose or application of Fire Danger Rating" and "There is no agreement about the measures of 'fire business' the NFDRS is expected to track/emulate." The NFDRS-East Workshop report (USDA Forest Service 1986) noted that "No method or procedure exists for validation and/or testing NFDRS performance." The Final Report on Fire Management Policy (USDA/USDI 1989) states that "Validation of the relationship between current fire management information system components (that is, drought indexes, energy release component, 1,000 hour fuel moisture, and so on) with actual fire occurrence, severity and size is needed." More recently, the South Canyon Fire Investigation report (USDA/USDI 1994) included a recommendation that "Present fire danger levels should be compared to historic averages and worst case conditions, and the selection of appropriate suppression response should be adjusted on the basis of this information." The procedures, methods, and the FIRES computer program described here address these issues.

Fahnestock (1975) noted that "All fire danger rating systems have one thing in common: their users are never satisfied with them" and that "agencies are continually seeking better interpretations of the various codes and indices in terms of operational experience." We offer the FIRES program as an aid in that interpretation.

The Fire Information Retrieval and Evaluation System (FIRES) is a computer program that provides methods for evaluating the performance of fire danger rating indexes and for defining critical levels of fire danger. We expect that FIRES will be used by land managers using fire danger rating in decisionmaking as well as by researchers evaluating new indexes. Five potential applications are as follows:

- *Interpretation of fire danger indexes.* FIRES relates indexes to fire activity on a percentage or probability basis. This helps to emphasize that NFDRS can't be used to predict the behavior of individual fires. Proper interpretation of fire danger indexes will give users increased confidence in the system and reduce confusion with fire behavior prediction.
- *Choice of appropriate index and fuel model.* NFDRS offers many index and fuel model options. FIRES provides an objective way to make an appropriate choice for an area. Andrews and Bradshaw (1996), for example, examined the use of various fuel models and indexes for Yellowstone National Park.
- *Decision levels.* Critical levels for an index are often defined using percentile levels without regard to fire activity. FIRES provides index percentile information plus an analysis of the relationship of indexes to historical fire occurrence and size. Fire danger levels can thus be better determined for a variety of fire management needs. Deeming (1983) pointed out the importance of this application: "There is little hope the NFDRS or any updated version of the NFDRS will be satisfactory in the eyes of fire managers until the manning class problem is resolved." Andrews and Bradshaw (1995) illustrated the use of FIRES in using NFDRS as an element in the go/no-go decision for prescribed natural fire.
- *Choice of weather station.* Fire danger rating depends on the availability of reliable daily weather observations. It is expensive to maintain and operate these stations. A comparison of fire activity in a management area to indexes based on weather taken at several weather stations can indicate which is most representative.
- *Revision of NFDRS.* A test of the performance of indexes as related to fire business based on historical fire records can identify weaknesses in a fire danger rating system and indicate whether a proposed change is warranted. Several drought indexes, for example, can be compared to determine which best relates to fire activity in various climate zones.

Methods

Fire danger rating produces indexes that give an indication of fire potential for a large area. NFDRS developers Deeming and others (1977) state: "The NFDRS will not predict how every fire will behave. Other systems fill this need." Fire behavior prediction applies to a specific fire, whether for real-time prediction of an ongoing fire or for gaming a fire under hypothetical conditions for planning applications.

A test of fire behavior prediction methods involves recording fuel, weather, and terrain information for the site along with associated fire behavior. Rate of spread and flame length can be observed and measured. Predicted and observed values can then be compared (Andrews 1980, Norum 1982, Rothermel and Rinehart 1983) to evaluate the performance of the system. An evaluation of fire danger rating is not as easily defined. What goes on the "observed" axis of a similar plot to illustrate the performance of an NFDRS index?

Although the calculation of Burning Index is related to flame length divided by 10 (Deeming and others 1977), one wouldn't expect flame length to be the same for all of 24 hours of the day for every location in the rating area. Calculation of flame length is a fire behavior prediction function. There may be a relationship between flame length and NFDRS indexes (longer flame lengths on higher index days), but NFDRS should not be expected to predict flame length itself.

In addition, a problem with using observed fire behavior in evaluation of fire danger rating is that fire behavior observations are difficult to obtain. For example, Williams (1983) reported an attempt to compare Burning Index and observed flame lengths. To find out why the correlations were not as high as expected, he questioned users on how they measured flame lengths. He concluded that "The results showed that only 4 percent of those surveyed knew how to measure flame lengths and none of these had the responsibility for filling out the fire reports that the study was dependent on." Haines and others (1983, 1986) successfully used observed fire behavior to test NFDRS in the Northeastern United States. In addition to data recorded on standard fire report forms, they gathered additional information on fire behavior and fuel on 940 wildfires. Similar, more inclusive studies, however, would be nearly impossible because of the time, effort, and expense involved.

Our goal in developing the FIRES program was to use methods that could be widely applied without requiring additional data collection. We go beyond a research study in which fire danger rating is evaluated for a specific area and time. FIRES allows fire managers to do analysis of fire danger rating in an operational setting. To this end, we use historical records of fire occurrence and final size as measures of fire activity. The data are readily available and generally reliable (Donoghue 1982). Discovery date and size class of a fire can be put in such terms as fires per day and probability of a large-fire-day.

The three dependent variables that we use are "**fire-day**," which has a value of 1 if one or more fires were reported on that day, and 0 otherwise; "**large-fire-day**," which is 1 if one or more fires that were reported on that day had a final fire size over a specified number of acres, and is 0 otherwise; "**multiple-fire-day**," which is 1 if more than a specified number of fires are reported on that day, and is 0 otherwise. Each classification is done separately; a day that is a large-fire-day is also a fire-day. The user defines "large" and "multiple"; we use 10+ acres and 5+ fires as defaults in the program and in the examples in this paper.

Figure 1 is a plot of final fire size versus discovery day Burning Index (fuel model D) for Black Creek National Forest in Mississippi. Linear regression analysis gives $R^2 = 0.06$; it would be an understatement to say that this indicates a poor relationship. The scatter should be no surprise considering all of the variables involved in influencing final fire size.

Figure 2 is based on the same data as is figure 1. Each day is classified as either a fire-day or not and as a large-fire-day or not; the percentage of days in each of five index classes that are fire-days or large-fire-days are shown

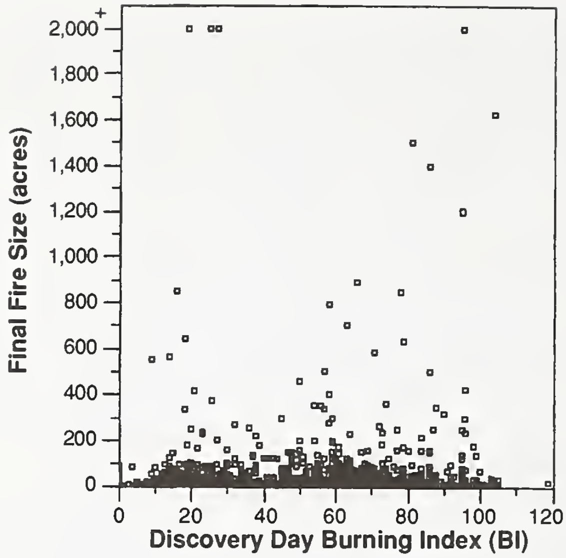


Figure 1—Final fire size versus Burning Index (fuel model D) on day of discovery for the Black Creek National Forest in Mississippi, 1974 through 1994.

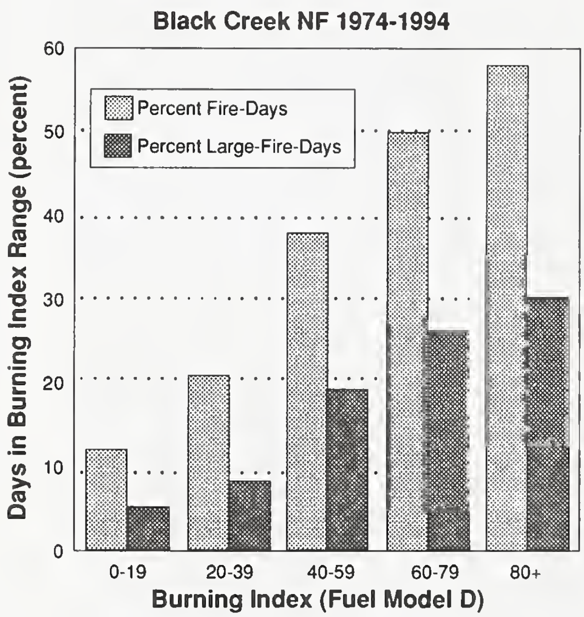


Figure 2—Same data used in figure 1 expressed as percentage of the days for each BI range on which fires were discovered (fire-days), and the percentage of days on which fires with final size over 10 acres were discovered (large-fire-days).

in the bar chart. By looking at the data this way it becomes apparent that there is a relationship between fire danger and fire activity measured in terms of fire occurrence and size. The percentage relationship shown in figure 2 supports the philosophy of fire danger rating. Fires are more likely to occur on higher index days, and fires that occur on those days are more likely to get larger.

Thinking in terms of percentages and probabilities may take some effort. Paulos (1988) used the example of the TV weather forecaster who announced that there was a 50 percent chance of rain for Saturday and a 50 percent chance for Sunday, and concluded that there was therefore a 100 percent

chance of rain that weekend. Another of Paulos' examples of a person not understanding probabilities: "A man who travels a lot was concerned about the possibility of a bomb on board his plane. He determined the probability of this, found it to be low but not low enough for him, so now he always travels with a bomb in his suitcase. He reasons that the probability of two bombs being on board would be infinitesimal."

Fahnestock (1975) put the interpretation of fire danger rating in perspective with a half-page article: "Playing the Odds, or What the Canadian Fire Weather Index Means in Alberta." He showed the relationship of fire occurrence and area burned to the Fire Weather Index (FWI) on a ratio basis. He concluded: "Anybody who thinks it's fun to buck the 2:3 odds at Las Vegas with his own money should be deliriously happy to stake government funds on the FWI with the odds strongly in his favor."

Fire-day is a good measure of fire activity and is much more than an indicator of occurrence. To be included in a wildfire data base, a fire must have been reported and declared a wildfire. If a fire occurs but is not detected, or if it is controlled by nonagency personnel and not reported, it is not in the data base. For example, if people are burning ditch banks and the fire gets away from them but they control it themselves, it is not reported and not in the data base. If they need help in controlling the fire, it is reported and we count it in our analysis. If the fire danger rating system is working, the escape is more likely to occur on a day with a high index. Another example is that a lightning storm may result in ignitions that just smolder until the fire danger rises when they "take off" and are reported. Recall that we use date of discovery rather than estimated ignition date in our analysis.

Many factors are obviously ignored by considering only the discovery date and final size of fires to indicate fire activity. For example, a fire may have become large because of lack of available suppression forces rather than because of high fire danger. On the other hand, a fire may have been controlled when small because extra forces were available as a result of the high fire danger. Nevertheless, a sufficient amount of historical data expressed in terms of percentages will give an indication of overall fire activity. We are not attempting to predict the behavior of every fire. An occasional "bad" fire occurs on a day with "low" fire danger, but that does not mean the danger rating system has failed. However, if a high percentage of such fires occur on days with "low" fire danger, then there is reason for concern. We must learn to "play the odds" in applying NFDRS to fire management decisions.

In the FIRES program, the relationship between fire danger rating indexes and fire activity is examined by comparing percentiles for all-days, fire-days, large-fire-days, and multiple-fire-days (Andrews 1987) and by logistic regression, which gives probability of a fire-day, large-fire-day, and multiple-fire-day as a function of index (Loftsgaarden and Andrews 1992). This allows an evaluation without predefined index intervals. The analysis is then, in fact, used to set fire danger intervals. In later sections we explain percentiles and probabilities using examples, an overview of logistic regression, and an explanation of the statistics produced by FIRES.

FIRES can be used with indexes from any fire danger rating system, including systems under development. Because, however, all of the examples in this paper are for the U.S. Fire Danger Rating System (NFDRS), we include here a review of the system.

Fire danger rating provides a way to integrate and interpret seasonal weather trends; fuel and terrain factors are essentially held constant. NFDRS uses daily fire weather observations and forecasts to produce indexes that are indicators of fire danger or fire potential for large areas. Weather readings are taken once per day at the same time and location. The National Fire Danger Rating System is based on a worse-case approach. "Worse case" means that it is an afternoon reading, when weather is close to the hottest and driest, and is taken in the open, often on a south-facing slope. It doesn't matter how good the NFDRS equations are, the time and space resolution of the basic input data precludes the possibility of an index predicting the behavior of a specific fire.

Figure 3 is a simplified diagram of the key parts of the NFDRS (Andrews and Bradshaw 1992). (A complete diagram can be found in appendix E of the

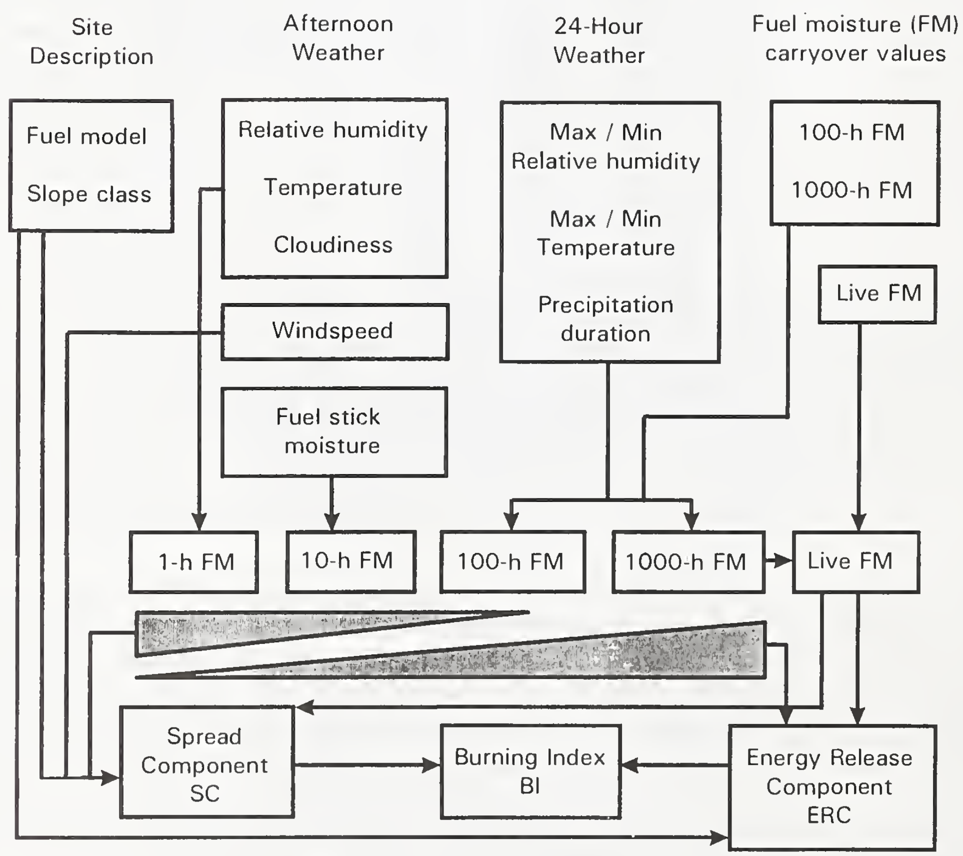


Figure 3—National Fire Danger Rating System (NFDRS) system overview (simplified) showing input values and intermediate calculated moisture values and their relationship to SC, ERC, and BI.

WIMS Users' Guide USDA Forest Service 1995.) Note in this diagram that the calculation of Spread Component (SC) is influenced most by the moisture content of fine dead fuel (1 h, 0-¼ inch diameter) and that windspeed is included in the calculations. On the other hand, Energy Release Component (ERC) is influenced most by heavy fuels (100 h and 1,000 h, greater than 1 inch diameter), and wind is not in the calculation. ERC thus gives a good reflection of longer term drying if there are heavy fuels in the fuel model. SC reflects daily variations in fine fuel moisture and wind. Burning Index (BI) combines SC and ERC.

Table 1 shows NFDRS fuel models sorted according to the fuel components that are included in the fuel model. Fuels that don't have the heavy

Table 1—National Fire Danger Rating Fuel Models (1978 option).

Fuel Model	Example vegetation / fuel type	Fuel Load, tons/acre						Fuel Depth, ft	Moist. of Ext. %
		1h	10h	100h	1000h	live woody	live herb.		
A	Annual grass and forbs	0.2					0.3	0.8	15
L	Perennial grass	0.25					0.5	1.0	15
N	Sawgrass	1.5	1.5			2.0		3.0	25
C	Open timber / grass	0.4	1.0			0.5	0.8	0.75	20
D	Southern rough	2.0	1.0			3.0	0.75	2.0	30
T	Sagebrush / grass	1.0	0.5			2.5	0.5	1.25	15
B	Mature chaparral	3.5	4.0	0.5		11.5		4.5	15
F	Intermediate brush	2.5	2.0	1.5		9.0		4.5	15
E	Hardwoods (winter)	1.5	0.5	0.25		0.5	0.5	0.4	25
P	Southern plantation	1.0	1.0	0.5		0.5	0.5	0.4	30
R	Hardwoods (summer)	0.5	0.5	0.5		0.5	0.5	0.25	25
U	Western, long-needle conifer	1.5	1.5	1.0		0.5	0.5	0.5	20
I	Heavy slash	12.0	12.0	10.0	12.0			2.0	25
J	Medium slash	7.0	7.0	6.0	5.5			1.3	25
K	Light slash	2.5	2.5	2.0	2.5			0.6	25
O	Pocosin	2.0	3.0	3.0	2.0	7.0		4.0	30
S	Alaskan tundra	0.5	0.5	0.5	0.5	0.5	0.5	0.4	25
H	Closed, short-needle conifer (normal dead)	1.5	1.0	2.0	2.0	0.5	0.5	0.3	20
G	Closed, short-needle conifer (heavy dead)	2.5	2.0	5.0	12.0	0.5	0.5	1.0	25
Q	Alaskan black spruce	2.0	2.5	2.0	1.0	4.0	0.5	3.0	25

component (100 h and 1,000 h fuel) don't reflect the seasonal trend that shows up in those fuel moisture values. Keep in mind that 1,000 h moisture may reflect the moisture content of not just large logs but also of the long timelag of duff. The fuel model name should be considered an example of the vegetation and fuel type that the model represents.

In addition to these 20 fuel models and the several indexes, the 1988 revisions (Burgan 1988) offer additional options including 20 revised fuel models and the Keetch-Byram Drought Index (KBDI) (Keetch and Byram 1968). (KBDI does not depend on fuel model; it is calculated primarily from maximum temperature and precipitation.)

Many applications of NFDRS depend on setting a decision level, above which some action may be taken: for example, prescribed fire activity ceases, the forest is closed to the public, or fire crews are kept on overtime. (NFDRS level is, of course, just one element that is used in making these decisions.) FIRES offers a way to set or refine decision points based on historical fire activity as well as index percentile levels. That important application of FIRES will be described later in this paper.

FIRES Information Flow—NFDRS Programs and Data

We give here a summary of programs and data bases that are directly related to the FIRES program to clarify how FIRES fits in with existing systems and how the data flows from one to another. Figure 4 shows the relationships and information flow, including file extensions used in FIRES. A summary of information for each element, including references, is given in table 2.

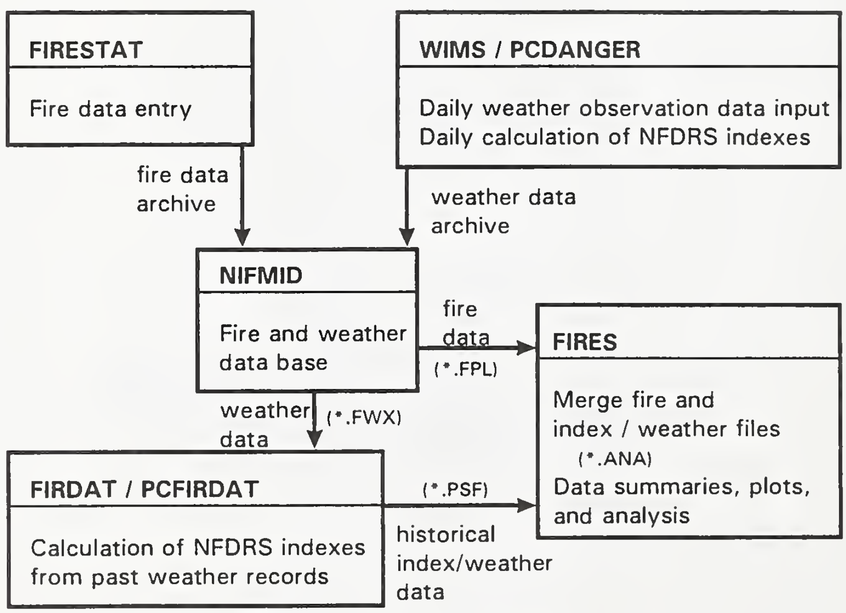


Figure 4—FIRES information flow. NFDRS programs and data bases that are directly related to the FIRES program.

Table 2—Programs and data bases related to the FIRES program, as diagramed in figure 4.

CATEGORY	NAME	SHORT DESCRIPTION	DESCRIPTION	REFERENCE
Fire and Weather Data	FIRESTAT	Fire Statistics (FS Fire Report 5100-29)	Electronic entry and storage of information from the Forest Service FS-5100-29 Individual Fire Report form. Files are periodically transmitted to the NIFMID data base.	USDA, Forest Service, 1996
	NIFMID	National Interagency Fire Management Integrated Database	ORACLE database on the USDA National Computer Center in Kansas City (NCC-KC) which stores historical data on weather (all agencies) and wildfire occurrence (currently only Forest Service).	USDA, Forest Service, 1993
Data Access	KCFAST	Kansas City Fire Access Software	Forest Service DG program. Utility to facilitate access to fire related data and applications at the NCC-KC. It is used to extract fire and weather data from NIFMID and to get the passing file of weather and indexes produced by FIRDAT (+ other uses not related to FIRES).	USDA Forest Service, 1996
	KCFASTPC	Kansas City Fire Access Software (PC)	PC program for access to NCC-KC. Subset of KCFAST. Uses SIMPC communications software to interface with NCC-KC.	USDA Forest Service, 1996
NFDRS Calculation from Daily Weather	WIMS (NFDRCALC)	NFDRS daily calculation on WIMS at NCC-KC	Calculation of NDFRS indexes from daily entry of weather data via WIMS: Weather Information Management System. Weather is archived in the NIFMID data base.	USDA Forest Service, 1995
	PCDANGER	NFDRS daily calculation (PC)	Calculation of NFDRS indexes from daily entry of weather data on PC. Weather data can be periodically transmitted to the NIFMID data base for archival. PCDANGER is based on the same NFDRS calculations as NFDRCALC, but is designed for PC and offers additional options. Weather scenarios can be entered for medium range projection of NFDRS indexes.	Bradshaw and Law, in press
Calculation and Analysis of NFDRS from Historical Weather	FIRDAT	NFDRS historical calculation	FIRDAT is one of the programs under the FIREFAMILY name. Calculation of fire danger indexes from archived weather files from NIFMID. A "passing file" containing weather and index values for each day is created.	Main and others 1990
	PCFIRDAT	NFDRS historical calculation (PC)	PC version of FIRDAT. Very few changes to design.	California Dept. of Forestry, 1994
Analysis of Fire and NFDRS Data	FIRES	Fire Information Retrieval and Information System.	Merges fire and weather/index files for analysis. Provides summaries, plots, and analyses and aides in determining most representative weather station(s), fuel model, and index for setting staffing levels.	Andrews and Bradshaw, 1997
Groups of Programs	FIREFAMILY	Family of fire danger rating programs for analysis of historical data.	FIRDAT--calculation of indexes SEASON--plots of data generated by FIRDAT	Main and others 1990
	PCFIREFAMILY	FIREFAMILY programs for PC.	Very few changes to design. PCFIRDAT and PCSEASON.	California Dept. of Forestry, 1994
	WIMS	Weather Information Management System	Programs and data bases at NCC-KC including NFDRCALC and NIFMID. FIREFAMILY programs can be accessed through WIMS by KCFAST utility.	USDA Forest Service, 1995

FIRES merges a file of historical fire data with a file of weather and fire danger index values. The resulting analysis file is used to produce data summaries, seasonal plots, and analyses. The programs and data bases diagrammed and described in figure 4 and table 2 are the defaults. A user, however, can define custom files for whatever index data are available.

FIRESTAT (Fire Statistics) (USDA Forest Service 1996b) is the U.S. Forest Service's system of entry and storage of fire data; it is run on a local computer, and fire data files are periodically transmitted to the National Interagency Fire Management Integrated Database (NIFMID) (USDA Forest Service 1993) on the USDA National Computer Center in Kansas City (NCC-KC). NIFMID is an Oracle data base designed to include interagency fire and weather data. It currently includes interagency weather data, but only Forest Service fire data. U.S. Department of the Interior agencies archive fire data using the Shared Applications Computer System (SACS) at the National Interagency Fire Center (NIFC) in Boise, ID. FIRES includes formats for USDI data and allows definition of a format for use of fire data from any other source.

Calculation of fire danger indexes from archived weather data is done either by the FIRDAT program (Main and others 1990) on the NCC-KC computer or by PCFIRDAT (California Department of Forestry 1994) on a personal computer (PC). Both programs offer 1978 and 1988 NFDRS options; PCFIRDAT closely follows the design of FIRDAT.

NFDRS indexes are calculated during the fire season from weather observations entered daily using either the Weather Information Management System (WIMS) at NCC-KC or the PCDANGER program (Bradshaw and Law, in press) on a PC. An important function of WIMS is an automatic archive of weather data. When PCDANGER or other programs on a PC platform are used, the user is responsible for periodic archiving of weather into NIFMID or another data base.

KCFAST and KCFASTPC (USDA Forest Service 1996a) are programs that generate job streams and submit them to the IBM mainframe computer at NCC-KC, eliminating the need for a person to learn IBM's Job Control Language. The programs are used mainly to query the NIFMID data base and to download historical weather data for all agencies and fire occurrence data for Forest Service users. They can also run FIRDAT on NCC-KC and download the passing file for local use.

FIRES Program Overview and Operation

We give here an overview of the FIRES program design. More detail with example output is given in following sections. Color plates give examples of graphic output. Additional information on system requirements and program installations is in appendix A, a sample run is in appendix B, formats of files are in appendix C, and instructions for exporting files are in appendix D.

Selection from the six words in the menu bar (fig. 5a) can be made with the arrow keys and enter or by typing the first letter. As an item is highlighted, "help" information appears at the bottom of the screen. There is limited mouse support on the menus and file selection windows; the mouse does not, however, work with the bar menus on the graphic screens. Choice of the menu item FILE, VIEW, or UTILITY brings down additional options. The escape key (ESC) takes you back a level.

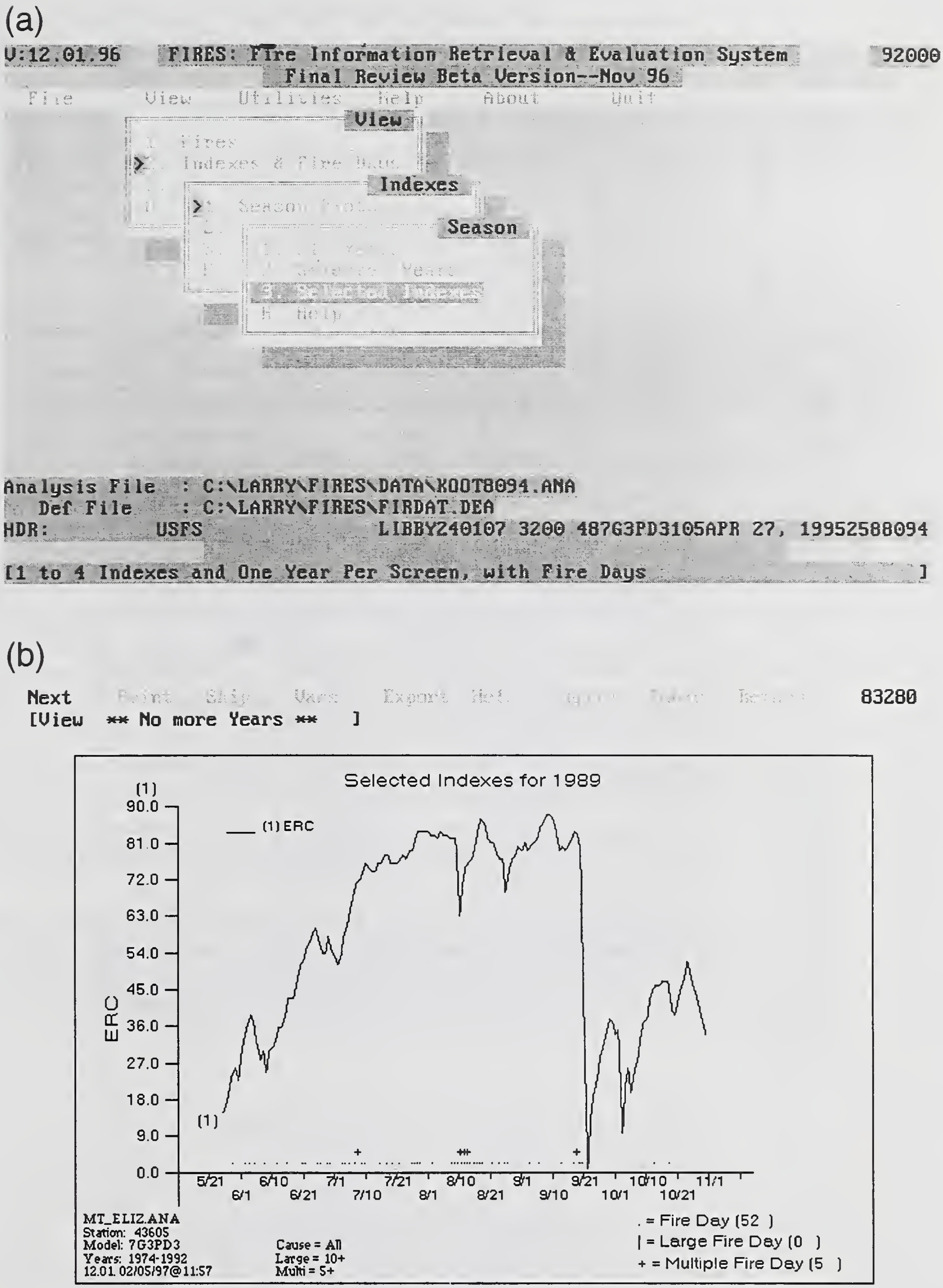


Figure 5—(a) Example FIRES screen showing main menu and drop down menus. (b) Example FIRES screen showing a seasonal plot and graph menu choices.

A bar menu also appears at the top of each graph screen (fig. 5b). The selection prompt is on the line below the menu. The prompt always starts on "Next", which allows you to view the next index (or year) in a series. If the currently displayed graph is the last of the series, as is the case in figure 5b, it is indicated in the prompt.

A quick reference of the menu items and options offered by FIRES is given in table 3. The specific actions for the graph bar menus are summarized in table 4. Following is an overview of some of the key menu items. Reference is made to the color plates, all of which are for the Stanislaus National Forest, Mt. Elizabeth weather station in California.

FILE allows you to open existing files or prepare new ones. A description of file preparation including how to define custom files is in the next section.

VIEW is the entry point to the core of the program—analysis and plotting.

Fire gives a quick summary of data from the fire file. The five bar charts on one screen show number of fires and acres burned per year, fires per month, size class, cause class, and number of fires discovered per day (color plate 1).

Indexes and fire days provides seasonal plots, percentiles, and probabilities using the merged fire/index data file, known as the analysis file. Season plots can also be done for an index file.

Seasonal plots can be done for selected years and indexes. Index extremes and averages, and fire occurrence can also be plotted. The All years option plots all years in the data file, 1 year and index per plot, six plots to a page (color plate 2). Selected years plots up to 4 years on a graph, one index at a time sequentially (color plate 3). And Selected indexes plots up to four indexes on the same graph, 1 year at a time sequentially (color plate 4).

Percentiles gives percentile curves for all-days, fire-days, large-fire-days, and multiple-fire-days for a selected index (color plate 5).

Probabilities uses logistic regression to produce curves for probability of a fire-day, large-fire-day, and multiple-fire-day as a function of a selected index (color plate 6).

Decision points gives key information on a screen to aid in setting decision points: percentiles and probability curves, and bar charts for all-days, fire-days, large-fire-days, and multiple-fire-days for the defined intervals. The bar charts change as the class breakpoints are changed (color plate 7).

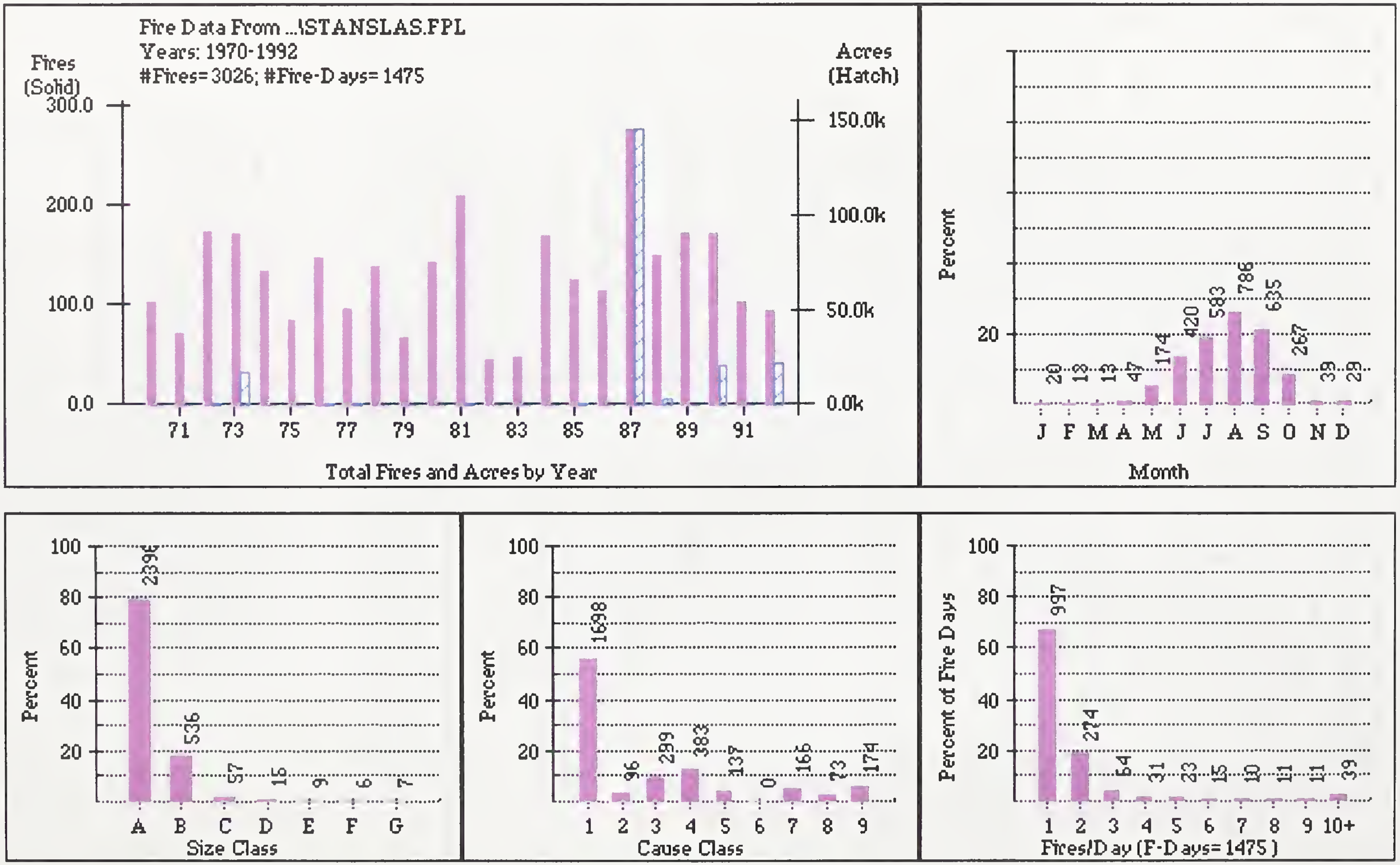
Table 3—Quick reference for FIRES main menu choices.

Main	Level 2	Level 3	Level 4	DESCRIPTION
File				Open or prepare files for analysis.
	Open			Open existing files.
		Fire		Open a fire occurrence file (*.FPL) and associated definition file (*.DEF).
		Index		Open an index (passing) file (*.PSF) and associated definition file (*.DEP).
		Analysis		Open a previously prepared analysis file(*.ANA) and associated definition file (*.DEI).
	Prepare			Prepare an analysis file for use or define non-standard index or fire file formats.
		Analysis		Merge an index file (*.PSF) and a fire file (*.FPL) into an analysis file (*.ANA).
		Fire		Define a non-standard fire occurrence file format (*.DEF).
		Index		Define a non-standard index file format (*.DEI).
View				Select index plots and analysis option.
	Fire			Plot summary of fire data. One screen, five bar charts.
	Indexes & Fire Days			Plots and analysis of an index or analysis file.
		Season plots		Seasonal plots for selected years and indexes.
			All Years	All years in the file. Six plots (6 years) per screen.
			Selected Years	1 to 4 years on the same screen. One index at a time.
			Selected Indexes	1 to 4 indexes on the same screen. One year at a time.
		Percentiles		Percentile curves for all days, fire-days, large-fire-days, and multiple-fire-days.
		Probabilities		Probability curves and statistics tables from logistic regression for all days, large-fire-days, and multiple-fire-days.
	Decision Points			Probability and percentile plots. Bar graphs and table for all days, fire-days, large-fire-days, and multiple-fire-days for classes of the index. Summaries change as divisions are changed.
Utility				Access utilities.
	Printer			Define printer driver
	DOS			Shell to DOS. Type EXIT to return to FIRES.
Help				General help on program and menu navigation
About				About FIRES program development, documentation, and version.
Quit				Quit FIRES.

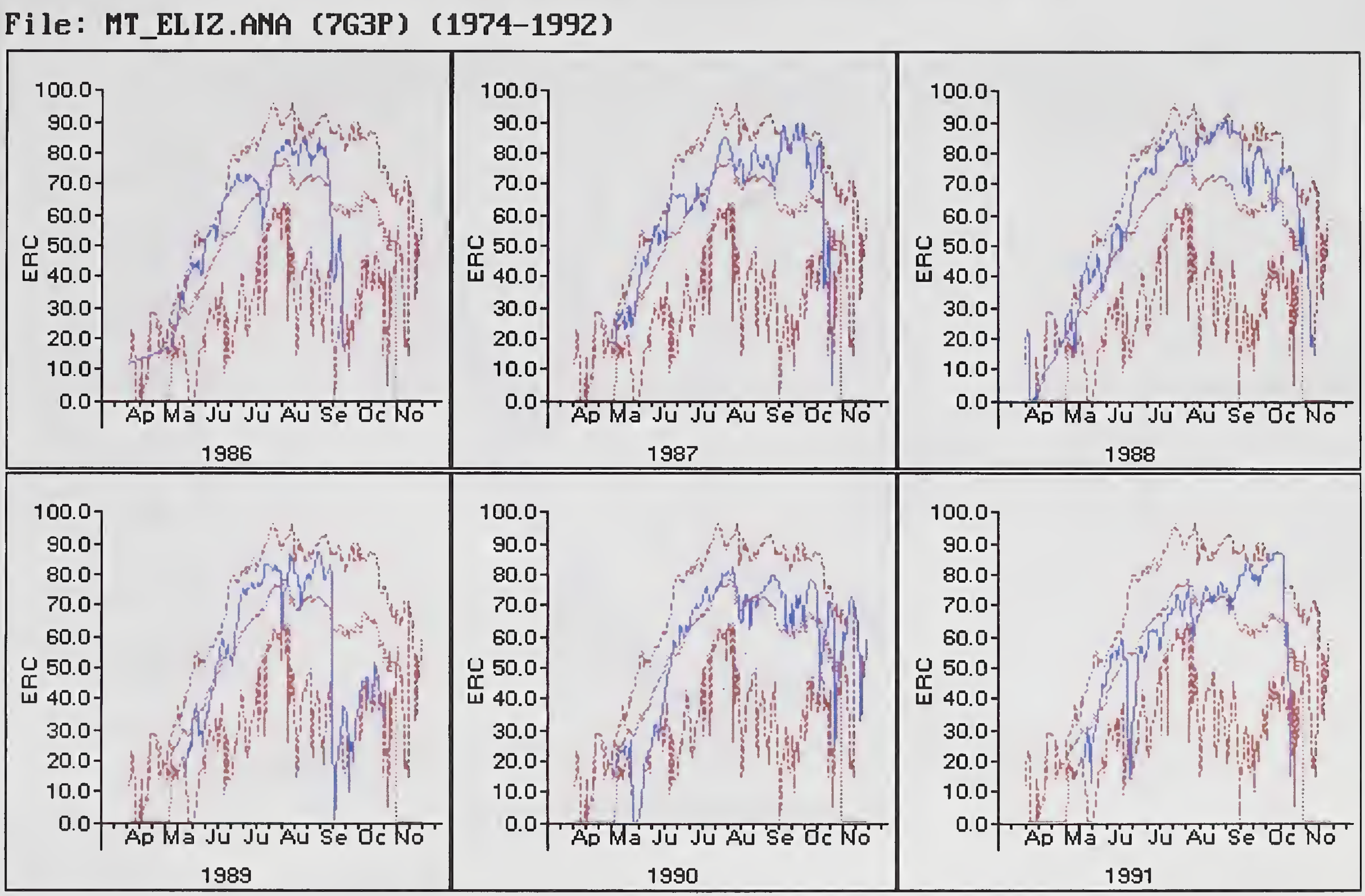
Table 4—Quick reference for FIRES graph menu choices.

Next	View the next graph for the variable displayed in the menu prompt.
Print	Print the graph which is currently displayed.
Skip	Skip the next of a series of selected variables.
Vars	Select new variables to graph from the pop-up menu.
Export	Export graph data to a file with comma-delimited ASCII format.
Help	Help screen for this menu.
Again	Redisplay the current graph.
Table	View graph data in table format.
Return	Return to previous menu.

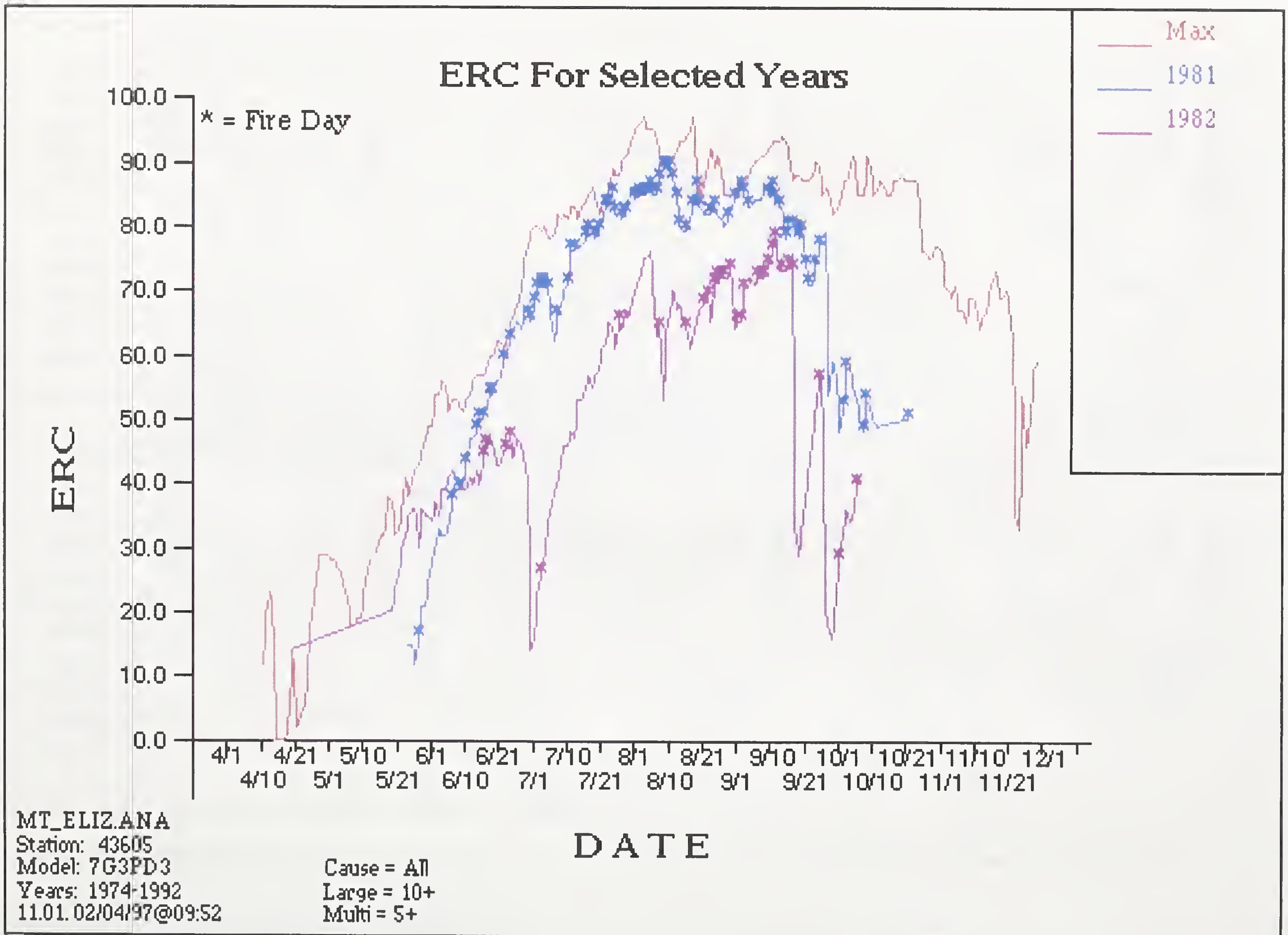
Color plate 1—Fire data. Fire data summary for 1970 through 1992. The number of fires and total acres burned are given for each year in the data base. Number and percent fires by month, size class, cause class, and fires per day.



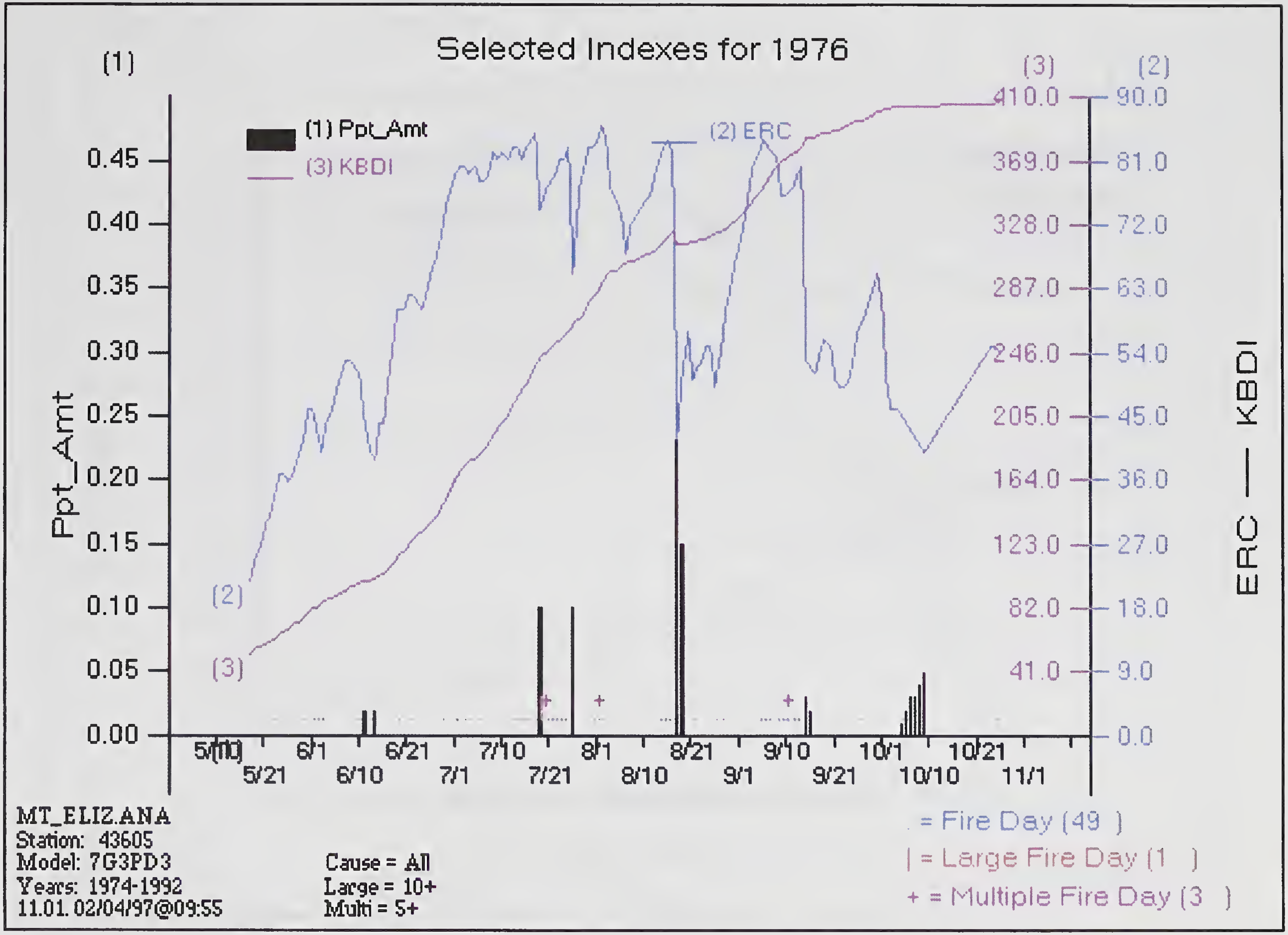
Color plate 2—All years. ERC for 1986 through 1991 with the maximum, minimum, and average ERC for 1970 through 1992.



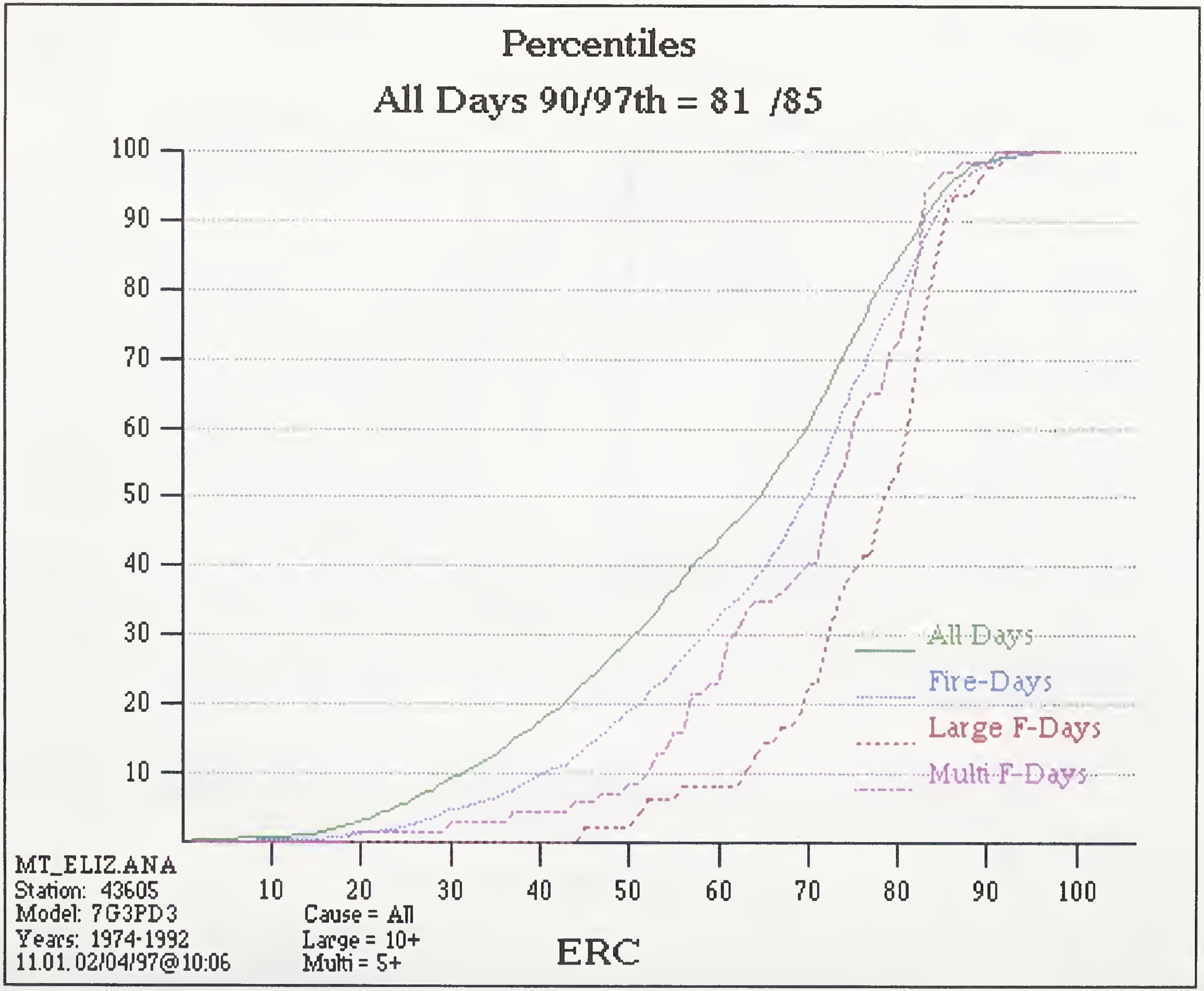
Color plate 3—Selected years. ERC for 1981 and 1982 with maximum ERC for 1973 through 1992. Fire-days are indicated with a *.



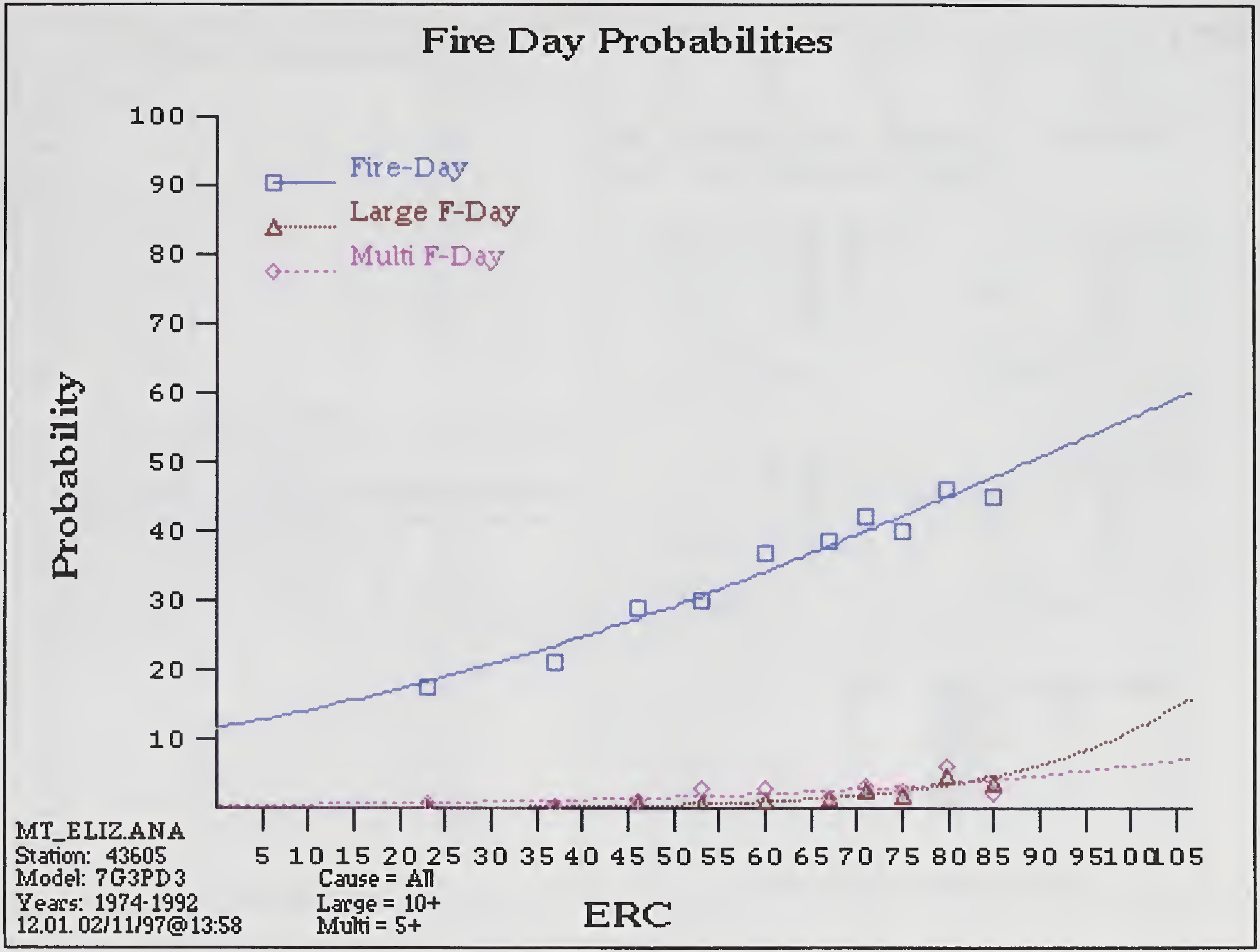
Color plate 4—Selected indexes. ERC, KBDI, and precipitation amount for 1976. Fire-days, large-fire-days, and multiple-fire-days are indicated by symbols above the x-axis.



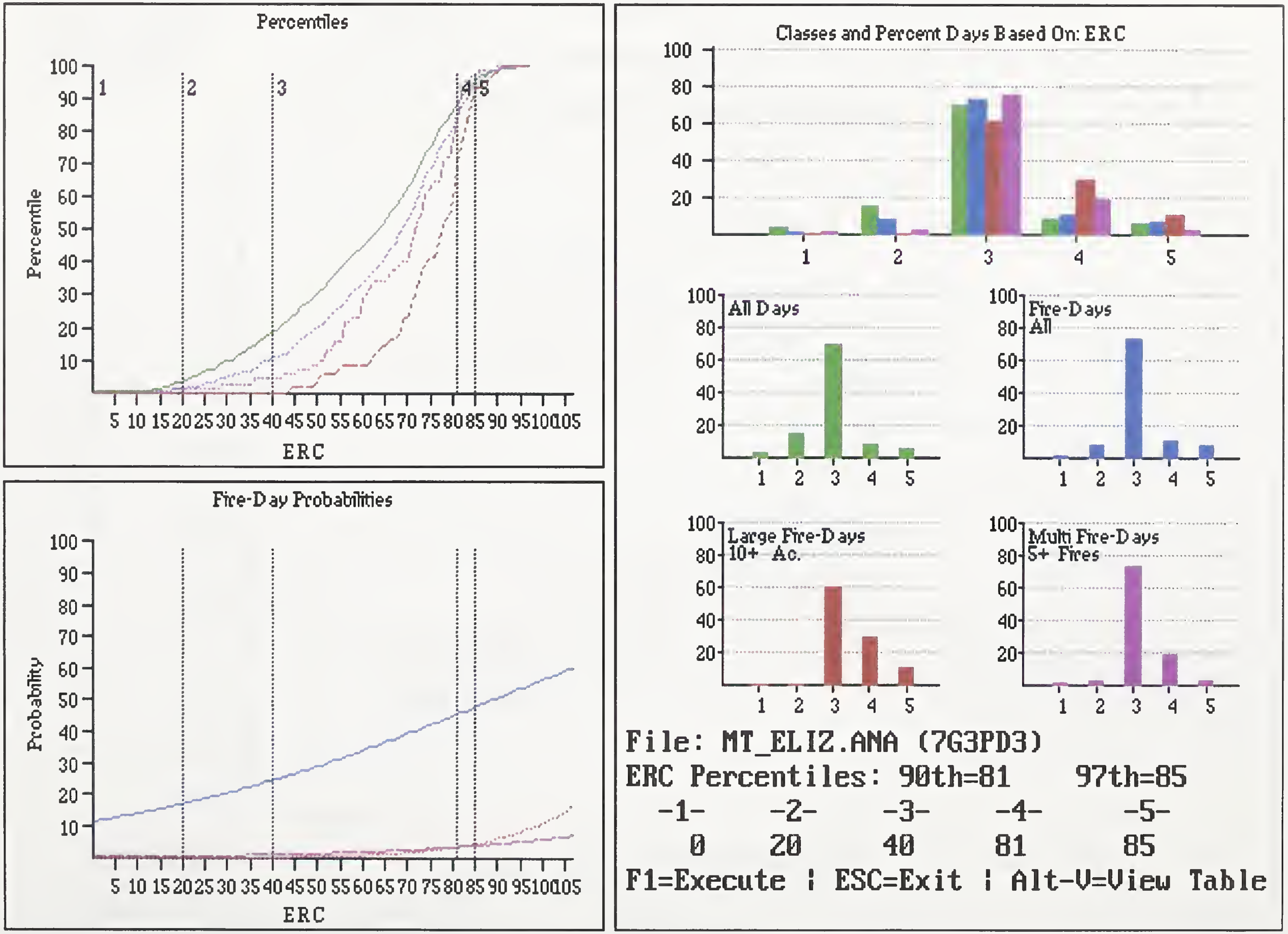
Color plate 5—**Percentiles**. Percentiles for ERC for all-days, fire-days, large-fire-days, and multiple-fire-days.



Color plate 6—Probabilities. Probability of a fire-day, large-fire-day, and multiple-fire-day as a function of ERC (fuel model G). Data points are percent of days in each interval labeled with the number of points that make up the percent.



Color plate 7—Decision points. Based on the default breakpoints for five staffing levels.



Data File Preparation and Export

File Types

The three main files types used by or generated by the FIRES program are fire occurrence files, index files, and a merged analysis file. File names are displayed on plots generated by FIRES for reference. File type is indicated by the extension as summarized in table 5. Formats are given in appendix C.

Fire occurrence data (*.FPL). "Fire" files contain information on discovery date, cause, final size, and location. The default source is NIFMID in the FPL or NFMAS format. Data are extracted from NIFMID using the KCFAST or KCFASTPC program. (Do not use the PCHA program.) The fire definition file, KCC_FPL.DEF describes this format to the FIRES program. DOI_FIRE.DEF defines the format (National format option) used by USDI agencies—Bureau of Land Management, National Park Service, Bureau of Indian Affairs, and Fish and Wildlife Service.

Index data (*.PSF). "Index" or "passing" files are output from the FIRDAT or PCFIRDAT program and contain weather and NFDRS index values for each day in the range specified.

Merged fire/index data (*.ANA). The fire file and the index file are merged by FIRES to create what we call an "analysis" file. It contains all of the information in the index file, plus fire activity information for each day. Each day is classified as a fire-day, large-fire-day, and multiple-fire-day (0 = no, 1 = yes). There is also information on the number of fires and total acres for fires discovered on that day. The file includes missing weather flags, the run length of a string of missing weather days. For example, if there is a string

Table 5—File naming conventions and extensions for FIRES.

FILE EXTENSION	CONTENTS	DEFAULT SOURCE	OTHER SOURCE
.FPL	Fire occurrence file	NIFMID (Forest Service)	BLM, NPS, FWS, BIA or user defined
.DEF	Fire occurrence file format definition file for (*.FPL)	KCC_FPL.DEF from NIFMID (Forest Service)	DOI_FIRE.DEF for USDI or user defined through **File|Prepare|Fire**
.PSF	Index File. Often referred to as a passing file.	FIRDAT or PCFIRDAT	User defined through **File|Prepare|Index**
.DEI	Index file format definition file for (*.PSF)	FIRDAT.DEI	User defined through **File|Prepare|Index**
.ANA	Analysis File. Merged index and fire file for use by FIRES.	Created by FIRES through **File|Prepare|Analysis**	n/a
.DEA	Analysis file format definition file for (*.ANA)	Created by FIRES through **File|Prepare|Analysis**. The format definition file name is stored as a header of the *.ANA file. (FIRDAT.DEA)	n/a
.SRT	Sort Command File for sorting non-standard fire file by date (yymmdd).	Created by FIRES through **File|Prepare|Analysis**.	n/a

of 5 consecutive days of missing weather, each day's missing weather flag will be 5. Zero (0) indicates that the day is an actual observation. Fires discovered on days in a string of more than 5 days of missing weather are discarded from most analysis routines. During creation of this file, weather and index values are supplied for missing days through one of three methods, which are defined as part of the index definition (*.DEI) file: linear interpolation, persistence, or filled with a user-defined value (for example, 0 or -9).

Definition files (*.DEF, *.DEI, *.DEA). To provide the needed flexibility, FIRES requires a definition file for each file type— *.DEF for *.FPL, *.DEI for *.PSF, and *.DEA for *.ANA. The definition files define variable names (long and short), the variable type (alpha or numeric), the length of the data field, whether the variable is independent (indexes) or dependent (fire-day), and the format for plotting the variable (line or bar).

Sort file (*.SRT). Sort key files are created by FIRES when you define a custom file type so that FIRES can correctly sort the files for aggregating and merging data.

Preparing an Analysis File

An analysis file is created by the FIRES program by merging a fire file with an index file.

- From the main menu, select **File**.
- From the File submenu, select **Prepare**.
- From the Prepare submenu, select **Analysis**.
- Select an index file (*.PSF) from the pop-up window.
- Press Enter to verify the data set, or enter 'N' to select different data or return to the Prepare submenu.
- Select an index definition file (FIRDAT.DEI or user defined) from the pop-up window.
- Select a fire occurrence file (*.FPL) from the pop-up window.
- Select a fire occurrence definition file (KCC_FPL.DEF, DOI_FIRE.DEF, or user defined) from the pop-up menu.
- Edit the analysis file parameters and press F1 to accept and build the analysis file.
- A process log will be displayed in a window at completion. The log file name is at the top of the window. It may be printed from the DOS prompt (you can shell to DOS from the Utilities submenu). An analysis definition file (*.DEA) is created and is automatically loaded when you later open the analysis file.
- Press Escape to return to the Prepare submenu.

Custom Data Files

FIRES allows you to define alternate file formats for both fire occurrence and weather/index files by creating new definition files.

A fire occurrence definition file (*.DEF) defines the format of your fire occurrence file (*.FPL). (There is a one-record format limit with a record

length up to 512 characters.) The FIRES program requires only six pieces of information from a fire occurrence record:

Discovery year

Discovery month

Discovery day

Fire cause code

Fire size code

Final fire size

To prepare a nonstandard or custom fire occurrence definition file, do the following:

- From the main menu, select **File**.
- From the File submenu, select **Prepare**.
- From the Prepare submenu, select **Fire**.
- Fill out all the fields in the Fire Occurrence File Structure Definition window. **Alt-H** provides help on field entries. Use a file name that has meaning to the format of your data (for example, CDF_FIRE).
- Press **F1** to accept the parameters and build the definition file (*.DEF) and the sortkey (*.SRT) file.
- Press any key to return to the Prepare submenu.

An index definition file (*.DEI) defines the format of your index file (*.PSF). The FIRES program requires four mandatory fields at the beginning of each record: station identifier (number or name), year, month, day. This is followed by a description of each weather or index field in your file. The following information is required for each field:

Long name

Abbreviated name (for display on graphs)

Data type (numeric or alphanumeric)

Total field length (columns)

Number of decimal places (if any)

Graph type for field (line or bar)

Missing day fill method (interpolation, persistence, fixed fill)

To prepare a nonstandard or custom index definition file, do the following:

- From the main menu, select **File**.
- From the File submenu, select **Prepare**.
- From the Prepare submenu, select **Index**.
- The first window allows you to name the new (*.DEI) file. Use a name that has meaning to the content of your index file (for example, HAINES or CANADA). This window also allows you to put a comment in the header structure of the (*.DEI) file that further describes the file format. Pressing F1 allows you to proceed to the actual data definition window. To abandon the process, enter **ESC** (after you have made an entry in the file name field).

- Fill out all the fields in the Index File Structure Definition window. The first four loops through the index window prompt you for the mandatory fields described above. The last question for each field asks if there is another index. Answer Y until you have defined all the indexes in your file. When you have defined the last field, answer N to the another field and the new definition (*.DEI) and associated sortkey (*.SRT) files will be built. To abandon the process, enter **ESC** at any time. **Alt-H** provides help on field entries.
- Select this new (*.DEI) file as the index definition file when opening your index file, either for viewing or preparing an analysis file.

Exporting Files

There may be a desire to do analysis or graphics beyond what the FIRES program offers. Analysis files are fixed field length and can be imported into most data base programs. Appendix D describes a data base "structure" definition file that can be used to create and import a FIRDAT-formatted analysis file into a standard data base (DBASE) program. In addition, an **Export** option is given with each plot that exports the specific graph data to a comma delimited ASCII file that can be imported directly into most spreadsheet and graphing programs.

Data Summaries

Before any serious analysis is done it is important to get to "know the data." For example, look at figure 6, for the Boundary Waters Canoe Area in northern Minnesota. These process logs are created as by-products of the **File | Prepare | Analysis** process.

Figure 6a is a summary of the index processing routine that fills in periods of missing weather data with weather and index values. Missing weather days are marked with the run length of the missing weather period. For example, 1986 had nine gaps in the weather stream with an average length of 1 day missing weather per event; 15 days of missing weather were filled. There were also nine gaps in 1992, but the average length was 5 days, and 47 days of weather were estimated.

Figure 6b summarizes the aggregated fire occurrence data. A summary by year gives total acres and the number of fires, fire-days, large-fire-days, and multiple-fire-days. The percentage of fire-days that are large-fire-days and multiple-fire-days is also given. In this example, there were 17 fires in 1991; they were discovered on 14 days (thus 14 fire-days). There were three large-fire-days that year, making it 21 percent of the fire-days (3/14).

Figure 6c summarizes the results of merging the index file and the fire file into an analysis file. The summary by year includes the number of weather records read from the filled index file, the fire records read from the aggregated fire file, the number of fire-days, nonfire-days, and the number of records written to the final analysis file. The right portion of the summary gives information on the number of fires and acres that occurred before weather records started and after they ended for each year. The column labeled "Miss Wx" gives the number of fires that occurred on days with

(a)

```
FIRES Routine          : Fill Weather 12.01. 02/05/97@12:22
Weather Input File     : C:\LARRY\FIRES\DATA\SEAGULL.PSF
Filled Wx Output File: WX.TMP
Wx Station Group       : SEAGULL                  210709
Defined Fire Season    : 01/01/86-12/31/92
```

Year	Wx Obs Read	Wx Obs Outside Season	Prds. of Missing Wx Obs	Average Period Length	Wx Days Estimated	Total Wx Days Written
86	148	0	9	1	15	163
87	158	0	0	0	0	158
88	147	0	5	1	6	153
89	142	0	2	1	2	144
90	137	0	4	4	17	154
91	149	0	2	8	17	166
92	112	0	9	5	47	159
7	993	0	31	3	104	1097

1097 Weather Records Written to: WX.TMP

(b)

```
FIRES Routine         : Aggregate Fire Days 12.01. 02/05/97@12:22
Fire Occurrence File: C:\LARRY\FIRES\DATA\BOUNDARY.FPL
Fire-Day Output File: FIRE.TMP
Defined Fire Season : 01/01/86 -12/31/92
Fire-Day Parameters : Cause=All       : Large=   10: Multi=  5
```

Yr	Total Fires	Total Fire Days	Large Fire Days Num	Large Fire Days % F-Days	Multi Fire Days Num	Multi Fire Days % F-Days	Total Acres
86	8	6	0	0	0	0	12
87	24	16	3	19	0	0	339
88	20	14	2	14	0	0	719
89	15	13	0	0	0	0	16
90	18	16	3	19	0	0	430
91	17	14	3	21	0	0	867
92	3	3	0	0	0	0	2
7	105	82	11	13	0	0	2385

```
  0 Fires Out of Defined Season (        0 Acres)
105 Fires Read From Occurrence File      : BOUNDARY.FPL
 82 Fire Days Written to Aggregate File : FIRE.TMP
```

(c)

```
FIRES Routine         : Merge Wx and Fires  12.01. 02/05/97@12:22
Weather Input File    : WX.TMP
Fire Input File       : FIRE.TMP
Merged Analysis File: C:\LARRY\FIRES\DATA\BOUNDARY.ANA
Defined Fire Season : 01/01/86 -12/31/92
Comment : Boundary Waters Wilderness Fires, Seagull FWX
```

Yr	Wx Recs Read	Fire Recs Read	Fire Days	Non Fire Days	Pre Wx Fires No.	Pre Wx Fires Acres	Post Wx Fires No.	Post Wx Fires Acres	Miss Wx
86	163	6	6	157	0	0	0	0	0
87	158	16	16	142	0	0	0	0	0
88	153	14	13	140	1	2	0	0	0
89	144	13	12	132	0	0	1	1	0
90	154	16	16	138	0	0	0	0	1
91	166	14	14	152	0	0	0	0	0
92	159	3	3	156	0	0	0	0	0
7	1097	82	80	1017	1	2	1	1	1

```
1097  Weather Records Read From : WX.TMP
  82  Fire-day records Read From: FIRE.TMP
1097  Analysis Records Written to: BOUNDARY.ANA
```

Figure 6—Data summaries generated under **FILE | PREPARE | ANALYSIS** for the Boundary Waters Canoe Area, Seagull weather station.

missing weather where the weather and indexes were estimated. FIRES discards from analysis fires occurring on days in a string of 5 days or more of missing weather. In assessing the quality of weather data from a station, it is important to note the number of fires that occurred on days with missing weather and the number of fires that occurred before or after the identified fire season.

View | Fire gives a summary of the fire data as five bar charts and in a table (see color plate 1). The five plots on a screen are number of fires and total acres burned for each year; number and percentage of fires by month, size class, and cause class; and number and percentage of fire-days by fires per day. Tables of values are also produced for this information. The default size class breakdowns and the cause class definitions are listed in appendix C.

Figure 7 shows the fire summary for the Lolo National Forest in Montana and the Black Creek National Forest in Mississippi. Both data bases include the years 1974 through 1994. There were 3,402 fires on the Lolo National Forest and 3,310 on the Black Creek National Forest. These fires occurred on 1,301 days (fire-days) on the Lolo National Forest and on 1,651 days on the Black Creek National Forest.

The upper left graph on figure 7 gives the number of fires and the total acres for each year to give a quick picture of differences in fire seasons. This chart can be used to identify high and low fire years for later examination with respect to fire danger indexes. The axes are scaled to accommodate the data. Notice that 1981 was a severe fire year in both number of fires and acres burned for the Black Creek National Forest (324 fires for 18,500 acres) while a high fire year for the Lolo National Forest was 1994 (411 fires for 11,074 acres). There was a 60,000 acre fire on the Lolo National Forest in 1988, a prescribed natural fire that was later declared a wildfire.

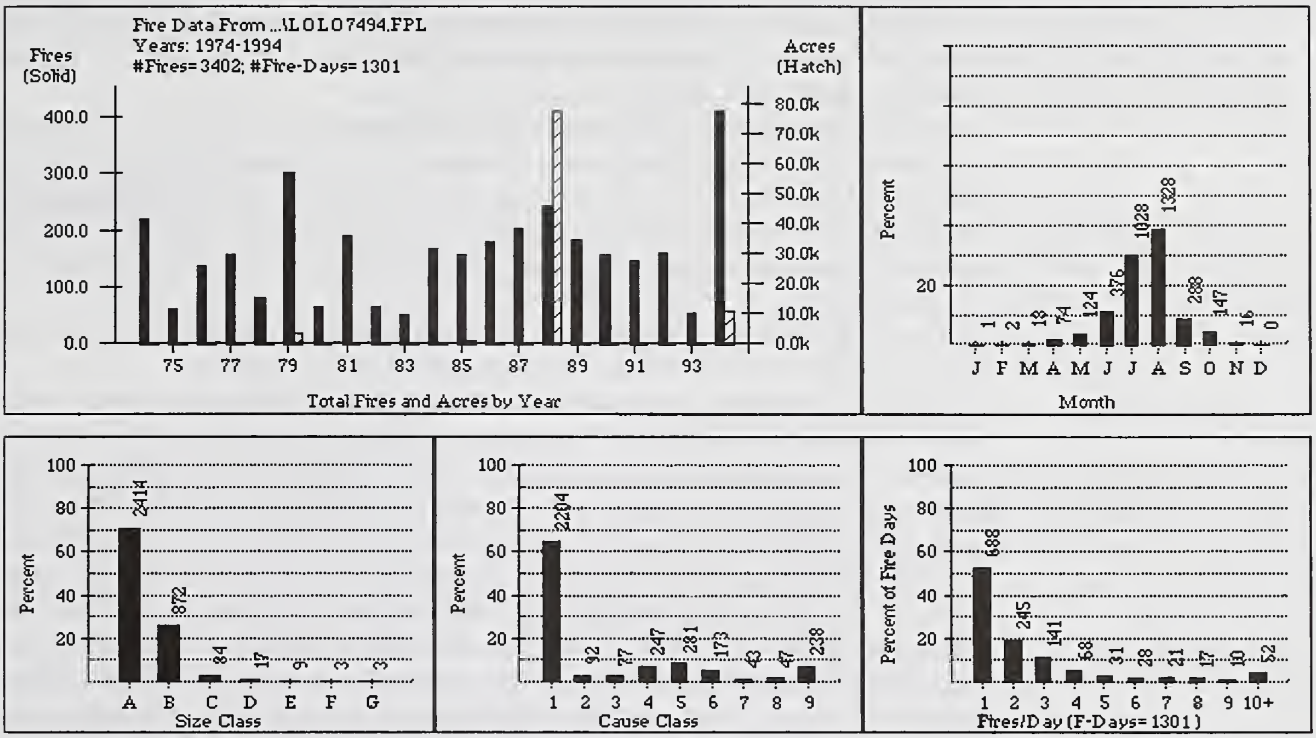
The difference in wildfire activity for the two sites is apparent by comparing the summaries: Montana fires occur in the summer months, most in July and August, while Mississippi has a year-round fire season with most fires occurring in the winter. Of the Lolo fires, 70 percent were less than 0.25 acre (size class A), while only 9 percent of the Black Creek fires fall into that category. And 65 percent of the fires on the Lolo National Forest were lightning fires (cause class 1), while 74 percent of the Black Creek National Forest fires were arson (cause class 7).

The tally of fires per day is not a record of the number of fires that are burning on a given day, but rather a record of days of multiple reports. A fire is counted on only 1 day—its discovery day. The distribution of fires per day is similar for the two sites in this example. Only one new fire was reported on 52 percent of the Lolo fire-days and on 55 percent of the Black Creek fire-days. Note, however, that on the Lolo National Forest, 4 percent of the fire-days (52 days) had 10 or more fire reports, compared to 0.5 percent (7 days) for Black Creek.

Seasonal Plots

A primary use of fire danger rating is to track the fire season and assess the level of fire danger. The numerical value of a fire danger index for a single day holds little meaning. It takes on meaning when examined with respect to other days in the season, other years, percentile levels, or maximum, minimum, and average values for that time of the year.

(a)



(b)

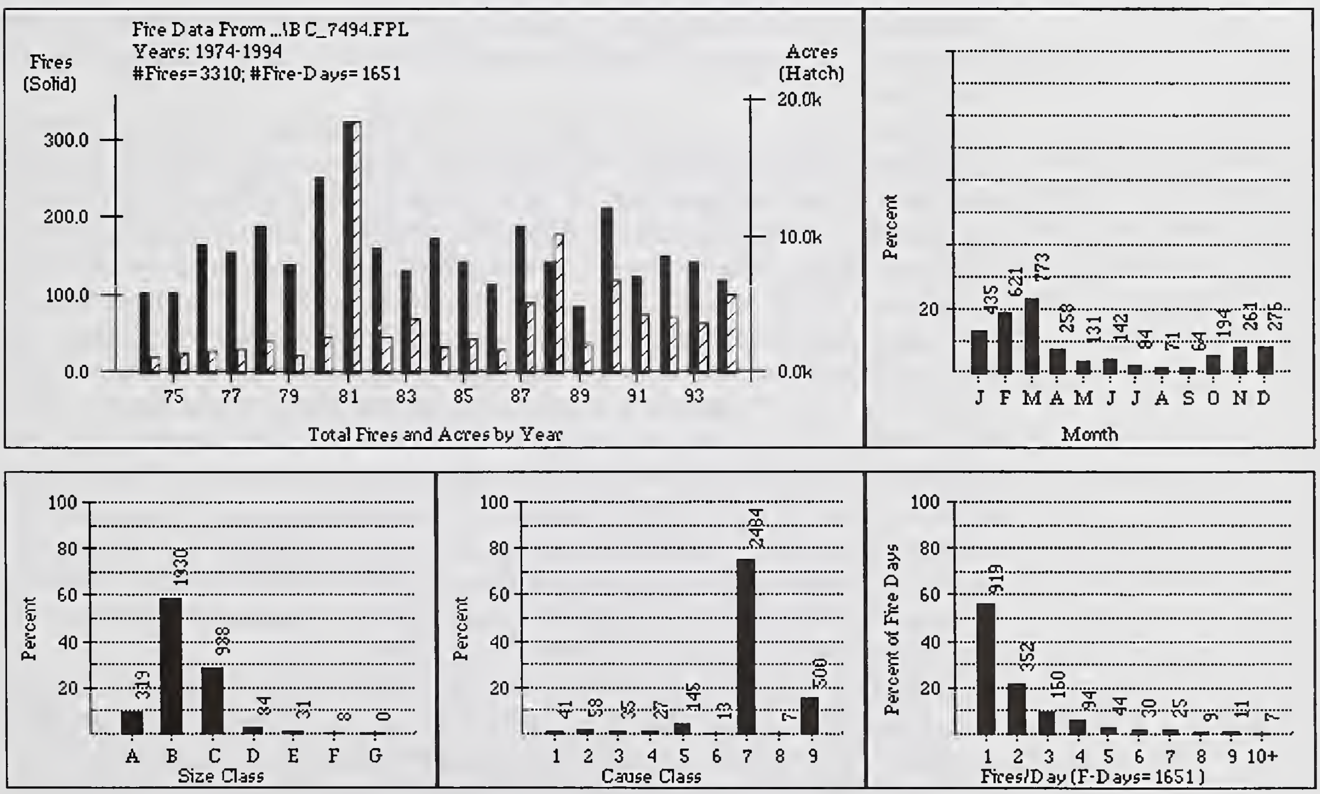


Figure 7—Fire summary for 1974 through 1994 for (a) Lolo National Forest in Montana and (b) Black Creek National Forest in Mississippi.

We use the word "index" for fire danger values, intermediate fuel moisture calculated values, and also for the weather variables. Any variable in the data file can be plotted. There are three choices for seasonal plots—all years for a quick review, one index and several years on a graph, or 1 year and several indexes on a graph.

It is often informative to see how a specific year compares to the maximum or minimum on record. Maximum, minimum, and average can be plotted on seasonal plots. There is no such thing as an "average year," but the average can show the fire season trend. Fire occurrence (fire-days, large-fire-days, or multiple-fire-days) can be plotted on the seasonal plots as a visual indication of fire activity.

View | Indexes & Fire days | Season plots allows you to choose the option of "All years," "Selected years," or "Selected indexes."

All years. A way to get a quick view of an index is to look at seasonal plots for all years in the data base. Six plots are printed per page, with one index per plot (see color plate 2). Figure 8 shows plots of Spread Component, Energy Release Component (fuel model G), and precipitation duration for 1980 through 1985 for the Libby weather station on the Kootenai National Forest in Montana. Maximum, average, and minimum can also be put on these plots, but they can get quite "busy." In this example, we've included the maximum for ERC for the period in the data base (1980 through 1994). They show up better in the color plots on the screen, of course, than in the black and white in figure 8. These plots allow a quick comparison of years and also of indexes. Notice the smoother response of ERC compared to SC. Refer back to figure 3 to remember how the two are calculated: SC reflects the quick response of fine dead fuels to changes in the weather and also includes windspeed in the calculation, while ERC is influenced mostly by the slower responding large dead fuels with no wind. Note in table 1 that fuel model G has 1,000 h fuels.

Selected years. Seasonal plots for up to 4 selected years can be put on the same graph (see color plate 3). Figure 9a shows a plot of ERC for 1993 compared to the maximum, minimum, and average for 1980 through 1994 for the Libby weather station on the Kootenai National Forest in northwestern Montana. Figure 9b shows the ERC trace of 1993 compared to 1994. The symbols on the plots indicate days on which fires with final size over 10 acres were discovered (large-fire-days). The user also has the option of plotting fire-days and multiple-fire-days. Fire danger for 1993 started out much higher than 1994, with "large" fires occurring on those higher index days in 1993. But 1993 became a low fire year, and 1994 was one of the worst on record. ERC reflected that fire activity well. There were no 10+ acre fires in 1993 after late May when the ERC dropped. But note the number of 10+ acre fires in July and August of 1994, corresponding with high ERC days. It is useful to relate years of memory for reference to the current year. People in northwestern Montana may be using the 1994 fire season as a reference for some time (Bradshaw and Andrews, in press).

Selected indexes. Plotting up to four selected indexes on the same graph helps a person understand the relationships among them. Figure 10 shows a plot of KBDI and precipitation amount for the Superior National Forest for 1976 and ERC and precipitation duration for the same year. This illustrates

influence of precipitation on the calculations. Fire occurrence is always plotted just above the x-axis with the "selected indexes" option; it shows up better in color and when the index chosen is not plotted as a bar (as is precipitation amount and duration). The number of fire-days, large-fire-days, and multiple-fire-days, and the definition of "large" and "multiple," are given at the bottom of the chart.

Percentiles

Percentile levels give an indication of the current situation compared to previous years in the data base. If a day has an index at the 97th percentile level, it means that only 3 percent of the days in the historical data base had an index higher than this.

We review the meaning of percentile through an example. Figure 11a shows the number of days with each ERC value for the Lolo National Forest for the years 1970 through 1984. Figure 11b is for the Black Creek National Forest for 1974 through 1987. The corresponding percentile curves are shown in figures 11c and 11d. The 90th percentile ERC value is 44 in both cases. That means that 10 percent of the ERC values were 44 or above. The 97th percentile ERC is 49 for both.

A suggested method for setting fire danger classes is documented in Helfman and others (1987) and used in WIMS. The lower level of each class is determined as follows:

Class 5 = Extreme = 97th percentile index

Class 4 = Very high = 90th percentile index

Class 3 = High = ½ of the 90th percentile index

Class 2 = Moderate = ¼ of the 90th percentile index

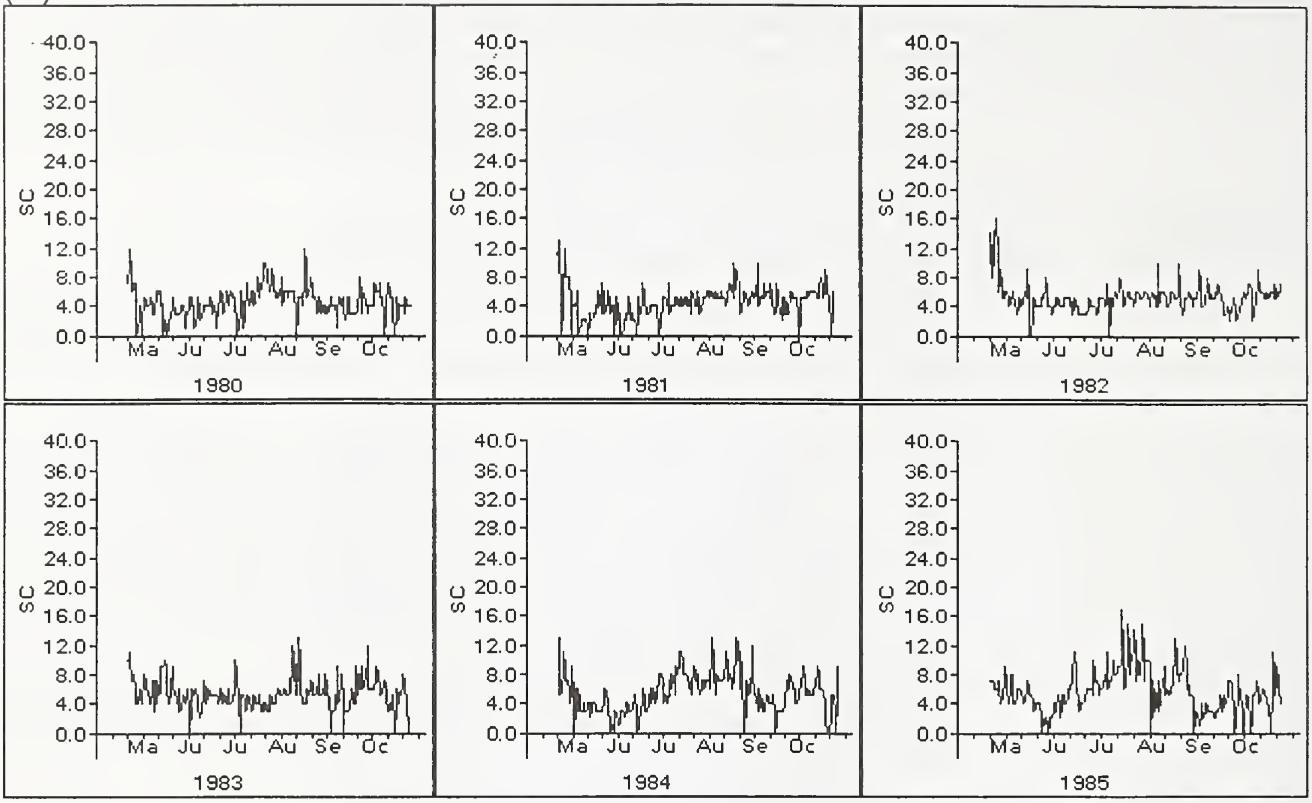
Class 1 = Low = zero

The results for this example are shown in figures 11e and 11f. Although the distribution of ERC values is different for the two sites, the resulting fire danger classes are the same because they are based on only the 90th and 97th percentile levels, which coincidentally are the same. Figures 11e and 11f show the percentage of days that fall into each class. We include this example not only to review the meaning of percentile but also to emphasize the point that more meaningful fire danger levels can be set if information other than two percentile levels is used.

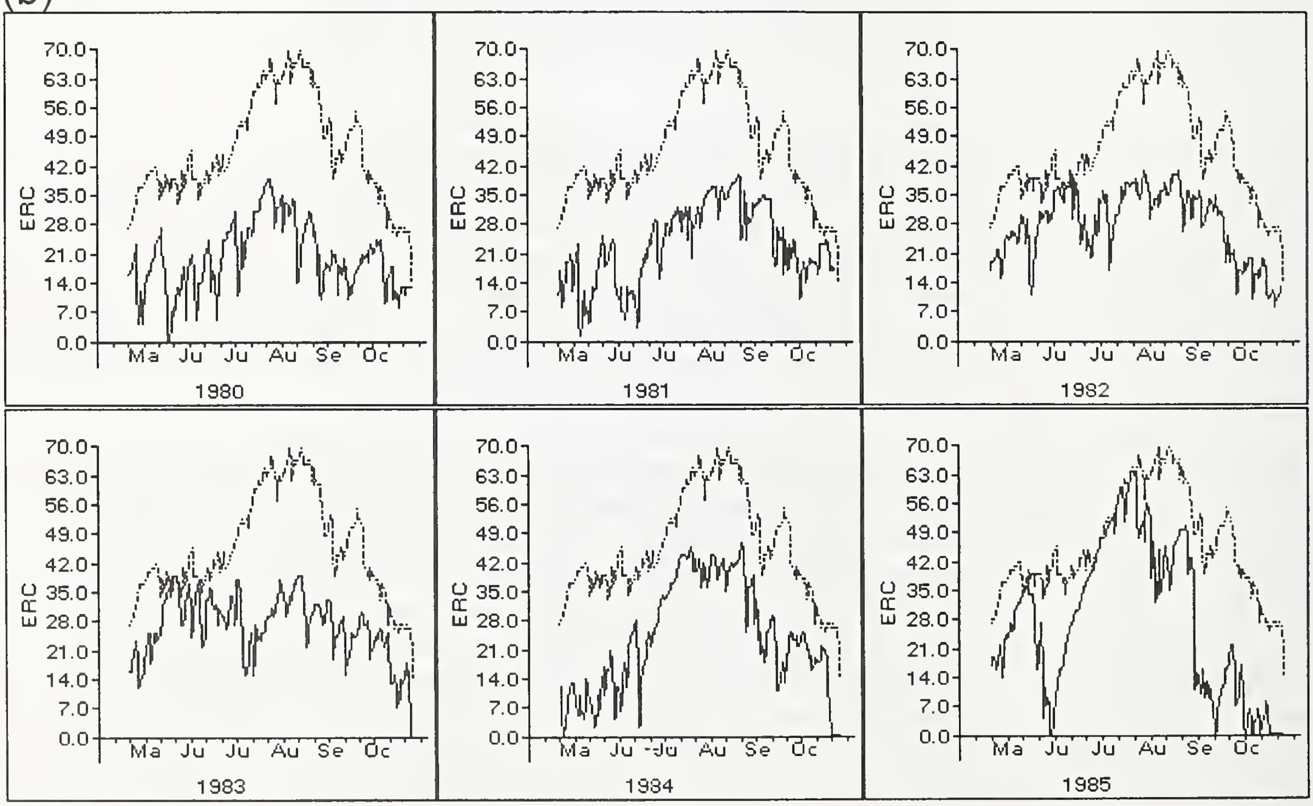
The percentile curves in figure 11 are based on index values from all-days in the data base. Consider the result of looking at only the indexes on days on which fires were reported (fire-days) and days on which only five or more fires were reported (multiple-fire-days). The comparison of the distributions and percentile curves for all-days, fire-days, and multiple-fire-days is shown in figure 12. It is clear that the distributions shift to the right. Although there are 2,501 days, 899 fire-days, and 117 multiple-fire-days (fig. 12a), the three distributions can be compared in terms of percentiles as shown in figure 12b.

The fact that the fire-day percentile curve is to the right of the all-day curve means that the fires are occurring on the higher index days. If there were no relationship between index and fire activity, the curves would be similar. The

(a)


SC
40.0
36.0
32.0
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
Ma Ju Ju Au Se Oc
1980
1981
1982
1983
1984
1985

(b)


ERC
70.0
63.0
56.0
49.0
42.0
35.0
28.0
21.0
14.0
7.0
0.0
Ma Ju Ju Au Se Oc
1980
1981
1982
1983
1984
1985

(c)

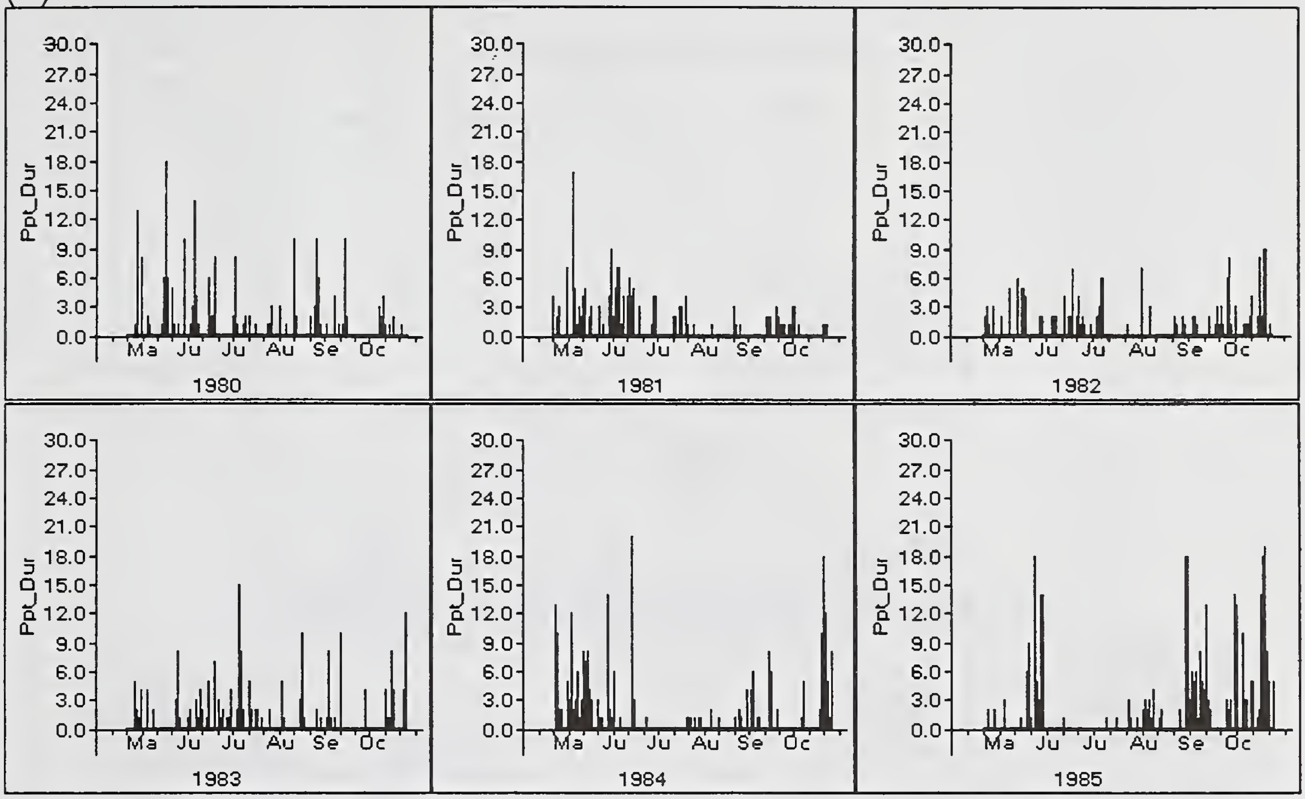
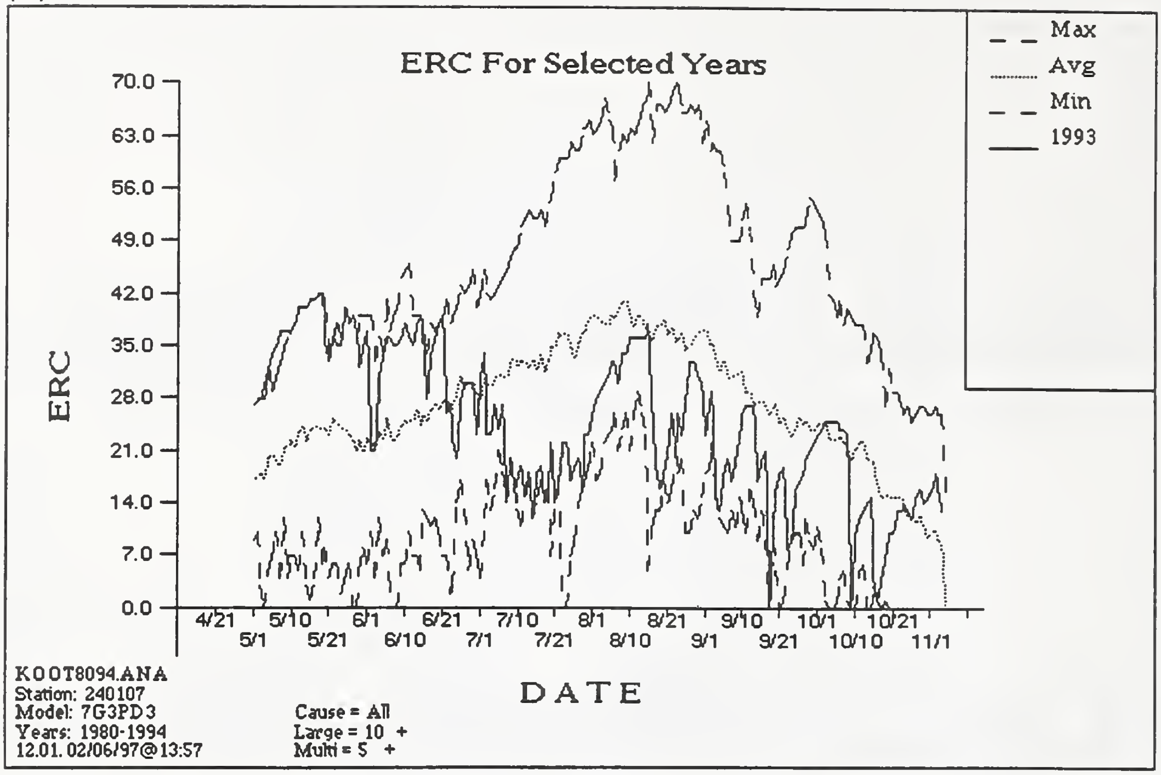


Figure 8—Quick view of each year in the data base, for chosen indexes from the ALL YEARS option for the Kootenai National Forest, Libby weather station, 1980 through 1985. (a) Spread Component (SC), (b) Energy Release Component (ERC) with maximum from 1980 through 1994, (c) precipitation duration.

significance of the shift in the percentile curves can be seen by choosing some values for comparison. Figure 13a shows that an ERC of 35 is the 64th percentile for all-days, 39th percentile for fire-days, and 17th percentile for multiple-fire-days. In other words, although only 36 percent of the days had an ERC of 35 or greater, 61 percent of the fire-days, and 83 percent of the multiple-fire-days fell above that level. Looking at the same information another way, figure 13b shows that the 30th percentile level is ERC of 26 for all-days, 32 for fire-days, and 38 for multiple-fire-days. That is, 70 percent of all-days had ERC above 26; 70 percent of fire-days were above 32; and 70 percent of the multiple-fire-days had an ERC above 38.

(a)



(b)

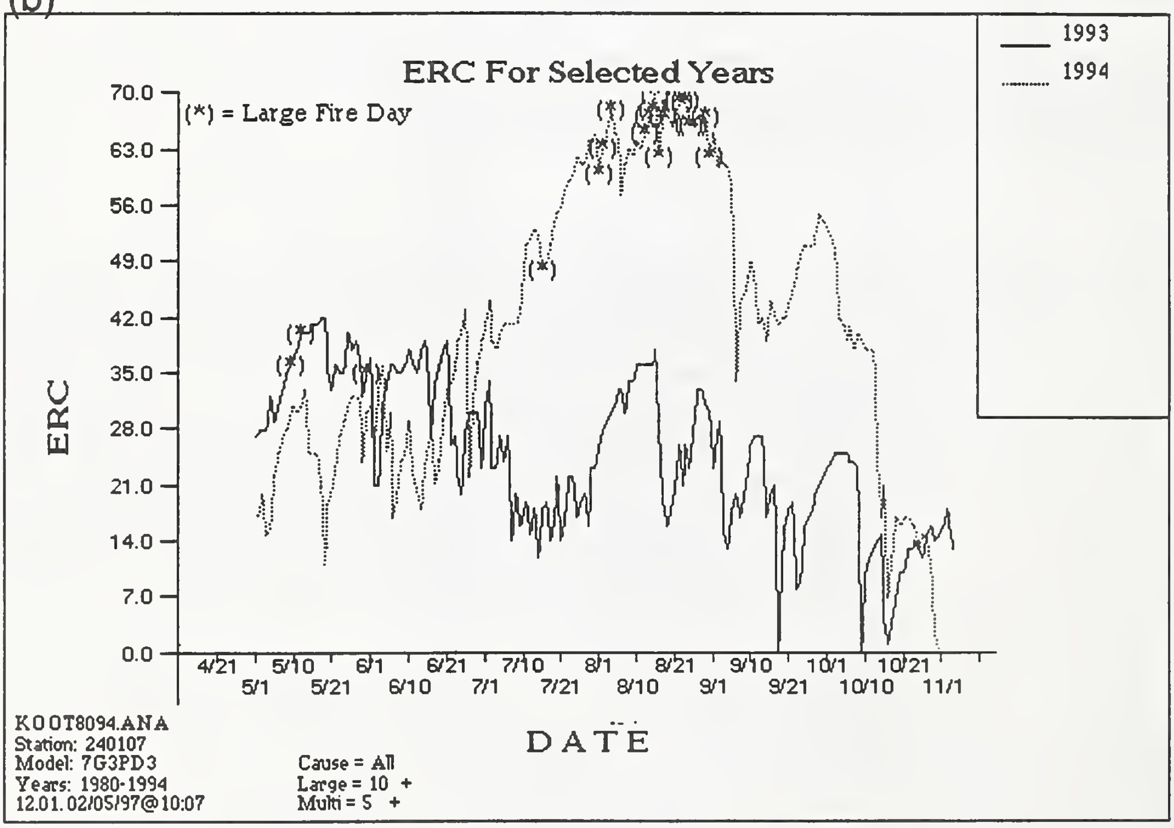
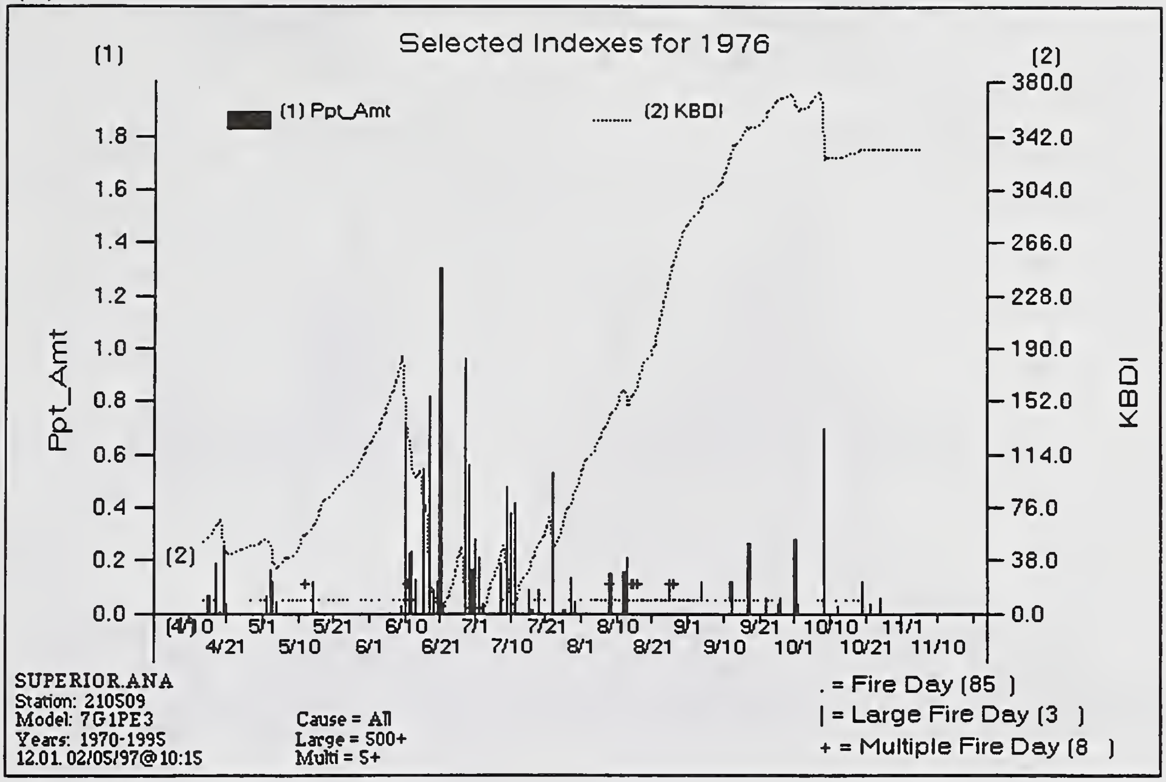


Figure 9—Selected years. Kootenai National Forest, Montana. (a) Energy Release Component, fuel model G for 1993 with maximum, minimum, and average ERC from 1980 through 1994, (b) ERC for 1993 and 1994 with large-fire-days are indicated with (*).

(a)



(b)

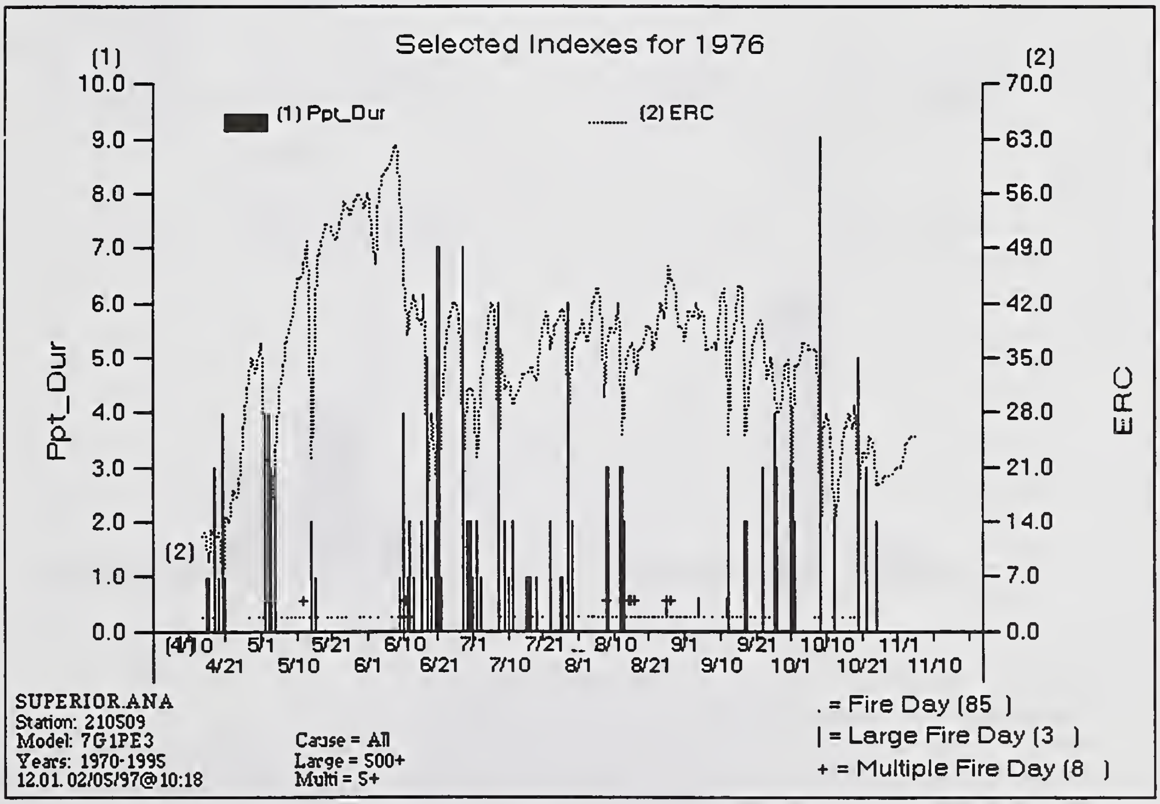


Figure 10—Selected indexes. Superior National Forest. (a) Keetch Byram Drought Index (KBDI) and precipitation amount for 1976, (b) Energy Release Component and precipitation duration for 1976.

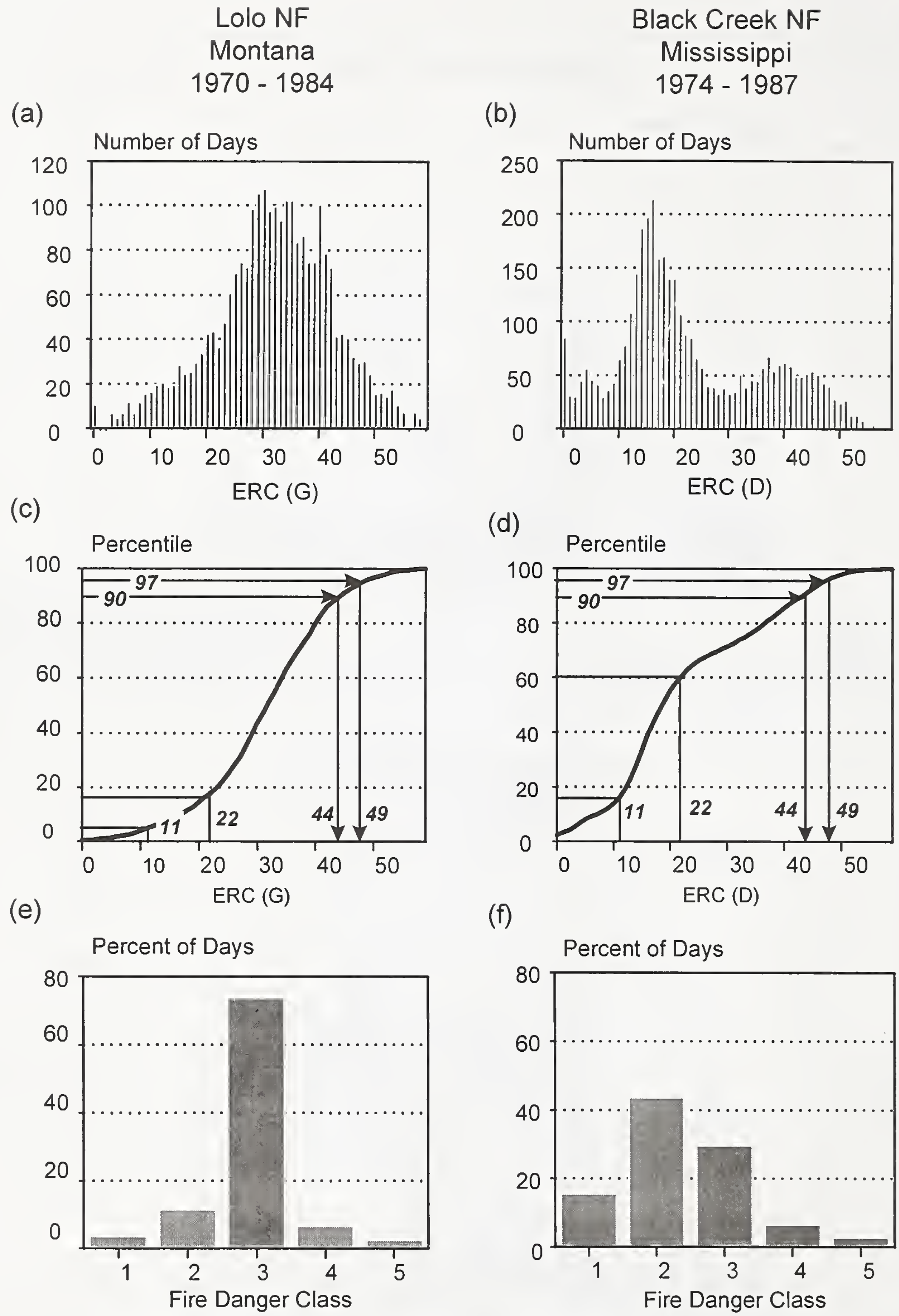


Figure 11—Black Creek National Forest in Mississippi, ERC, fuel model D, 1974 through 1987; and Lolo National Forest in Montana, ERC, fuel model G, 1970 through 1984. (a) and (b) bar graphs show the frequency of index values, (c) and (d) corresponding percentile curves, (e) and (f) percentage of days in each class when classes are based on 90th and 97th percentile levels and a suggested method of setting class divisions.

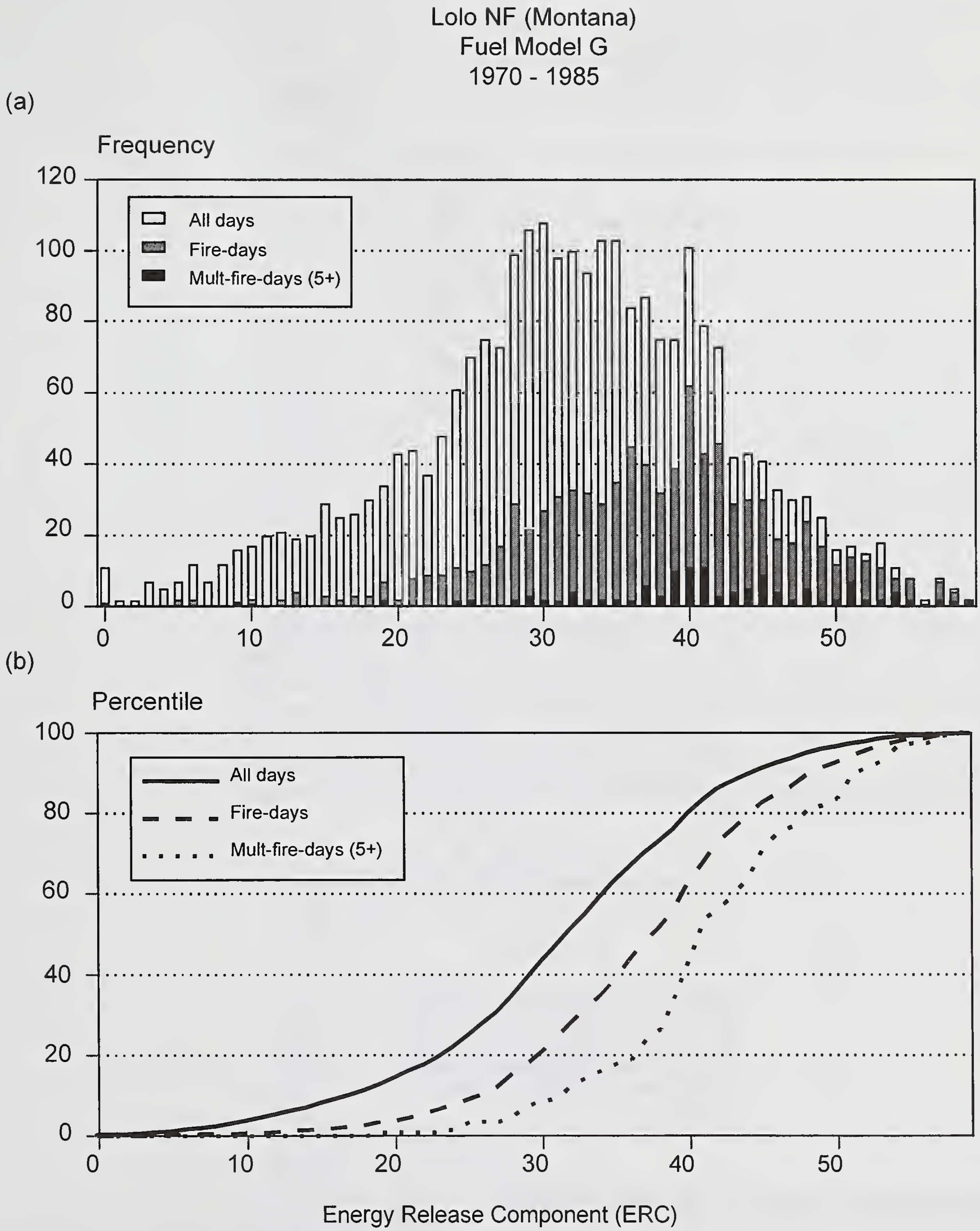


Figure 12—Lolo National Forest, ERC, fuel model G, 1970 through 1985. (a) Bar graphs for frequency of ERC for all-days, fire-days, and multiple-fire-days, (b) corresponding percentile curves.

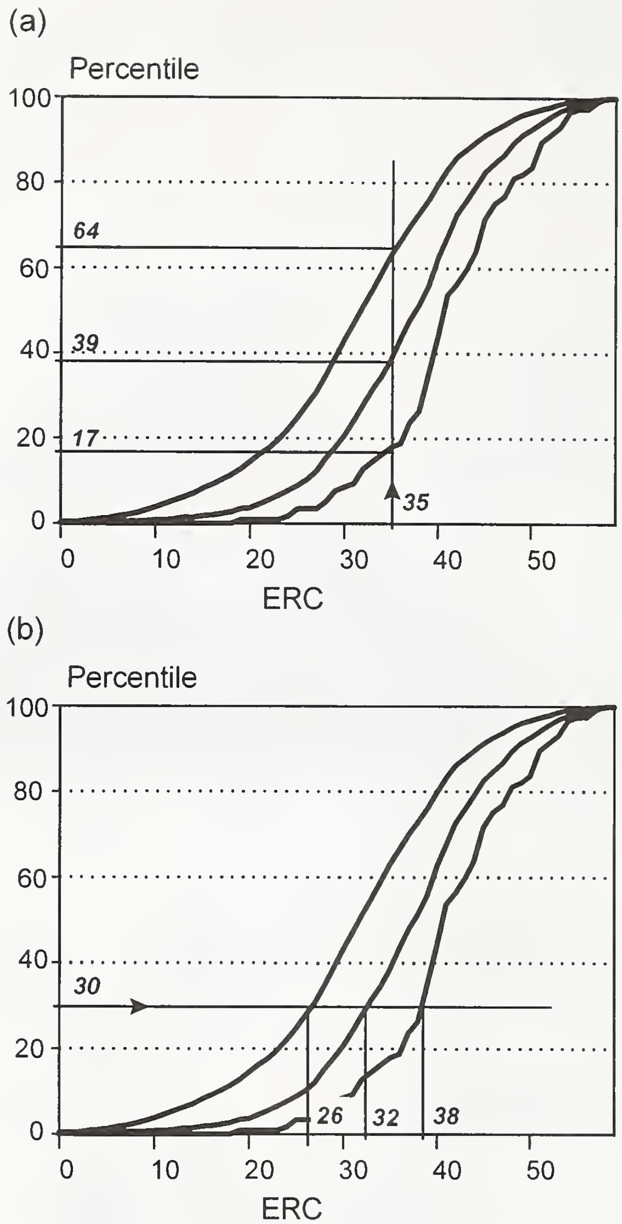


Figure 13—Example ways to read the percentile curves from figure 13b, for ERC for all-days, fire-days, and multiple-fire-days. (a) Percent days above ERC of 35, (b) ERC value above which 70 percent of the days fall.

Probabilities and Logistic Regression

The probability that a day is a fire-day (or a large-fire-day or a multiple-fire-day) as a function of index is determined by logistic regression as described by Hosmer and Lemeshow (1989) and Loftsgaarden and Andrews (1992). Logistic regression is a popular statistical tool for dealing with zero/one data. Examples of other applications include the following:

- An insect will live or die after a certain dose of spray (Stukel 1988).
- A tree will live or die after a fire (Ryan and Reinhardt 1988).
- A lightning strike will either start a fire or not (Latham and Schlieter 1989).
- At a given moisture content, a smoldering fire will continue to burn or go out (Hartford 1989).

In our case, each day is classified as a fire-day (1) or not (0), as a large-fire-day (1) or not (0), and as a multiple-fire-day (1) or not (0). Each day is classified three times. Logistic regression produces curves such as those shown in color plate 6.

Refer back to figure 12a, a bar chart of the frequency of all-days, fire-days, and multiple-fire-days for each ERC value. Figure 14 is based on the same data showing the fraction of fire-days in each interval (that is, the number of fire-days in that ERC interval divided by the total number of days in that interval). It is not appropriate to use ordinary linear regression to fit a curve through those points. The ERC interval from 10 to 19, for example, actually includes 241 data points (18/241 = 7 percent), while that for 30 to 39 includes 939 data points (325/939 = 35 percent). Figure 14 would, therefore, look different if other intervals were chosen. In addition, due to variations in the data, it is possible for probabilities to go down with increasing index. Logistic regression is a way to avoid these problems—the analysis is not based on predefined intervals, every data point is used (not just ratios for the data in an interval), and the resulting function gives increasing probability with increasing index.

Figure 15 shows logistic regression curves and associated data tables for Mount Pleasant weather station on the Tonto National Forest in Arizona. Figure 15a is the probability of a fire-day, large-fire-day, and multiple-fire-day given the ERC (fuel model G) on that day. Figure 15b is the same for BI

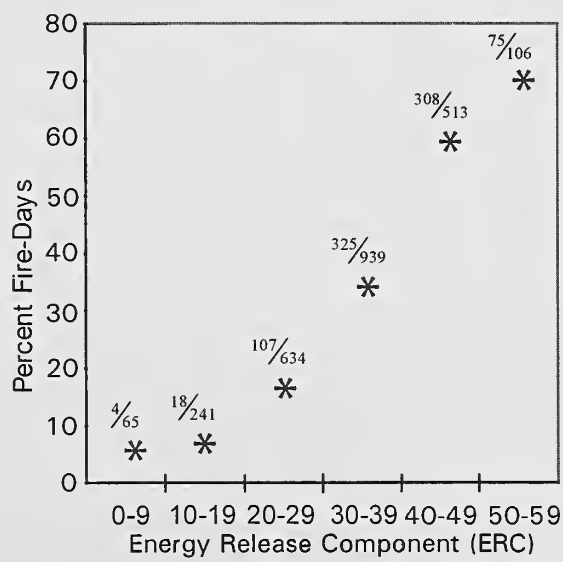
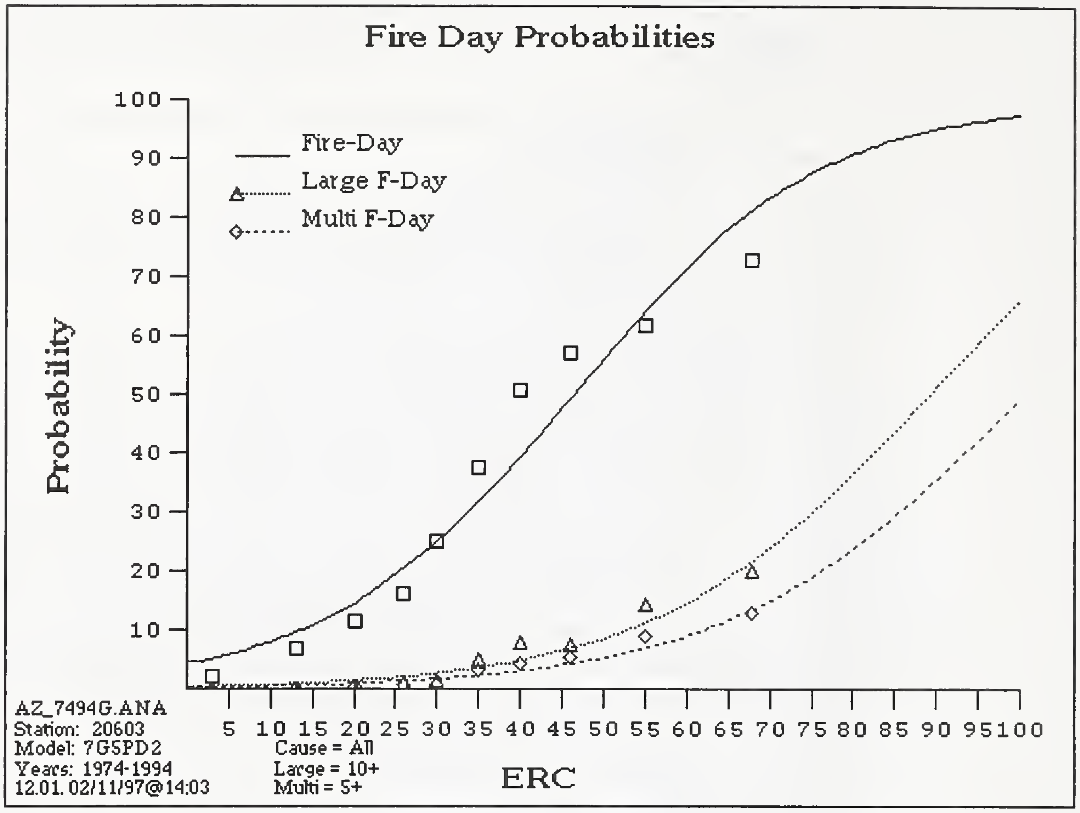


Figure 14—Fraction of fire-days in set intervals based on the data used for figure 12a.

(a)



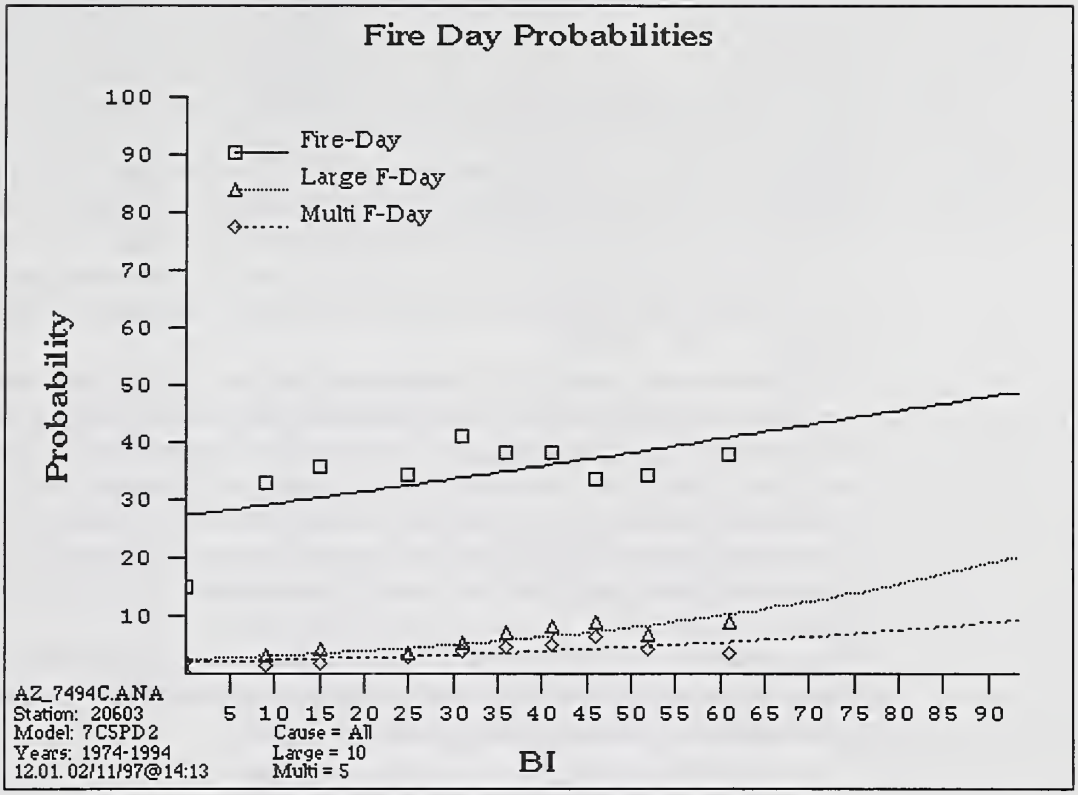

```
Analysis File: C:\FIRES\DATA\ARIZONA\AZ_7494G.ANA (7G5PD2)

    P(FDAY) = 1./(1.+exp(-1.* -3.1291+ (-1.*   .0675)*ERC))
```

Index-Rng Frm	Index-Rng To	Model-Prob Frm	Model-Prob To	Total Days	Fire Days	Obs Pct	Pred Fdays	FD Chi_Sq	NFD Chi_Sq	Total Chi_Sq
0	9	4	7	751	17	2	40	13.2	.7	14.0
9	17	7	12	751	50	7	74	7.7	.8	8.6
17	23	12	17	751	85	11	111	6.1	1.1	7.2
23	28	17	22	751	122	16	149	4.8	1.2	6.0
28	32	22	27	751	187	25	186	.0	.0	.0
32	37	27	35	751	281	37	234	9.5	4.3	13.8
37	43	35	44	751	381	51	297	23.9	15.6	39.4
43	50	44	56	751	428	57	376	7.1	7.1	14.2
50	60	56	71	751	463	62	481	.7	1.2	1.8
60	91	71	95	751	546	73	612	7.1	31.4	38.5
				7510	2560	34	2560	80.2	63.4	143.6

Chi_Sq	DF	p-value	SSTOT	SSE(1)	SSR(1)	DF	p-value	R(L)-Sq.
143.6	8	.0000	9637.1	7655.5	1981.6	1	.0000	.88
				SSE(S)	SSR(S)			
				7394.3	2242.8			

(b)



Analysis File: C:\FIRES\DATA\ARIZONA\AZ_7494C.ANA (7C5PD2)

P(FDAY) = 1./(1.+exp(-1.* -.9855+ (-1.* .0100)*BI))

Index-Rng Frm	Index-Rng To	Model-Prob Frm	Model-Prob To	Total Days	Fire Days	Obs Pct	Pred Fdays	FD Chi_Sq	NFD Chi_Sq	Total Chi_Sq
0	5	27	28	751	113	15	205	41.0	15.4	56.4
5	11	28	29	751	247	33	217	4.1	1.7	5.7
11	21	29	32	751	268	36	228	7.0	3.1	10.1
21	28	32	33	751	257	34	244	.7	.4	1.1
28	34	33	34	751	309	41	254	12.1	6.1	18.2
34	39	34	36	751	286	38	263	2.1	1.1	3.2
39	44	36	37	751	288	38	271	1.1	.6	1.7
44	49	37	38	751	251	33	280	3.0	1.8	4.8
49	55	38	39	751	257	34	290	3.8	2.4	6.2
55	85	39	47	751	284	38	309	2.0	1.4	3.4
				7510	2560	34	2561	76.9	33.9	110.7

Chi_Sq	DF	p-value	SSTOT	SSE(1)	SSR(1)	DF	p-value	R(L)-Sq.
110.7	8	.0000	9637.1	9577.2	59.9	1	.0000	.22
				SSE(S)	SSR(S)			
				9365.0	272.1			

Figure 15—Tonto National Forest, Mt. Pleasant weather station, Arizona. (a) Probability curves and statistics table for ERC, fuel model G, (b) probability curves and statistics table for BI, fuel model C for the same weather and fire data.

fuel model C). Both cases are based on the same weather and fire data. The difference is in the fuel model and index that were chosen for the NFDRS calculations. Because all of the data points are either zero or one, none of them fall on the logistic regression line. In this case there are 7,510 data points—2,560 ones and 4,950 zeros. The actual data points can't be effectively displayed with the curve (as is often done with ordinary linear regression) so they are grouped by interval, and the percentage of ones is plotted at the median of the interval. (The "Obs Pct" column in the table is "Fire Days" divided by "Total Days" times 100.) Intervals are defined such that there are an equal number of points in each. In this example, there are 751 points in each of the 10 intervals (see "Index Range" and "Total Days" columns).

We discuss here some of the statistics related to logistic regression: a test that indicates whether using the fire danger index is significantly better than using the overall percentage, a test of how well the logistic model fits the data, and a discussion of how two logistic models based on the same data set might be compared. Although the statistics might be useful to people who are doing a technical analysis of the data, we expect that many users of the FIRES program will be satisfied with a view of the plots and just skip the statistics table.

The logistic regression model gives the probability of a fire-day (or large-fire-day or multiple-fire-day) as a function of the independent or explanatory variable. The equation has the following form:

$$P(\text{FireDay}) = \frac{1}{1 + e^{-\hat{\beta}_0 - \hat{\beta}_1 x}}$$

The values of $\hat{\beta}_0$ and $\hat{\beta}_1$ are calculated by the logistic regression process; x is the value of the explanatory variable (the fire danger index). The equation for the curve in figure 15a (probability of a fire-day as a function of ERC(G)) is:

$$P(\text{FireDay}) = \frac{1}{1 + e^{3.1291 - .0675 ERC(G)}}$$

This is equivalent to the equation printed at the top of the table:

P(FDAY) = 1./(1. + exp (–1. * –3.1291 + (–1. * .0675) * ERC)

The probabilities calculated from this equation (and converted from fraction to percent) are given in the "Model Prob" columns.

The total sums of squares, SSTOT, is the variation in a model that has no explanatory variable in it–a model that is simply the proportion of fire-days for the entire data set, 2560/7510 = 0.34 or 34 percent for this example. For a logistic model constructed using one predictor variable, the "pseudo" sums of squares error, SSE(1), is the residual variation for this model. (We say "pseudo" because it is not a sum of squares but is used much like the sums of squares in ordinary regression.) The sums of squares residual, SSR(1) = SSTOT-SSE(1), is the explained variation for this model. The one in parentheses means that the model has only one explanatory variable in it—currently the only option in FIRES. SSR(1) has an approximate chi-square distribution with 1 degree of freedom and can be used to test that a significant improvement has been made when the model with one predictor variable is constructed. A small p-value indicates that a significant improvement has been made by adding the variable to the model. SSTOT, SSE(1), and SSR(1)

with associated p-value are given at the bottom of the table. In this example, for ERC(G), SSR(1) = 1981.6 with a p-value of 0.0000, indicating that this model provides a significant improvement over Prob = 0.34. The conclusion is the same for the logistic regression model based on BI(C).

The above test, however, is not a test of fit for the model. A test of fit must in some way compare observed data with that predicted using the model. For each of the 10 groups of data, as shown in the table, observed and expected number of fire-days and no-fire-days are found for each group. A chi-square test-of-fit statistic is computed as:

$$\chi^2 = \sum_{i=0}^{1}\sum_{j=1}^{10}\frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}}$$

Where O_{1j} and E_{1j} are the observed and predicted number of fire-days in group j for $j = 1,2\ldots10$, and O_{0j} and E_{0j} are the equivalent numbers for no-fire-days. This chi-squared statistic has 10 – 2 = 8 degrees of freedom. A small p-value for the chi-square statistic indicates a lack of fit of the model to the data. The table gives the contribution of each cell to the chi-square statistic, so that one can see where the model agrees and disagrees with the data. The higher values in the "Total Chi-Sq" column indicate poorer fit. The chi-square value of 143.6 with p-value of .0000 indicates a poor fit of the model to the data.

It is possible to calculate a value that is similar to R^2 for ordinary linear regression. We first define a "saturated" model as the fraction of 1's at each distinct value of the explanatory variable. (This model is rarely useful when two or more explanatory variables are being used.) In some sense we can think of the saturated model as being the data themselves. SSE(S) and SSR(S) are calculated and given on the table. For ordinary regression, the coefficient of determination, R^2, is defined as SSR/SSTOT. For logistic regression we modify this and define R_L^2 = SSR(1)/SSR(S). The subscript L indicates we are dealing with logistic regression. The smaller the difference SSR(S) – SSR(1), the closer R_L^2 is to 1. The closer R_L^2 is to 1, the better the logistic model fits the data as represented by the saturated model. In this example R_L^2 = 1981.6/2242.8 = 0.88 for ERC(G) and R_L^2 = 59.9/272.1 = 0.22 for BI(C).

It would be nice to be able to statistically compare the logistic model based on ERC(G) and the one based on BI(C). There is, however, no explicit test for comparing two different logistic models based on the same data but with each constructed using a different explanatory variable. The best that can be done is to compare the two models using the various statistics and other information that are available for each. A summary of statistics from figure 15 is given in table 6.

A model with a wide range of probability values is generally preferred to a model with a small range of values. In this example, the range for ERC(G) is 0.04 to 0.95 while it is 0.27 to 0.47 for BI(C). A good model should also have values of probability near zero. A 27 percent probability of a fire-day for BI(C) of zero is not a good feature. SSR(1) values are also useful in comparing two models constructed from different explanatory variables in the same set of data. A logistic model with an SSR(1) that is bigger than that for another model is in some sense "better." Compare SSR(1) of 1981.6 for ERC(G) to 59.9 for BI(C). The R_L^2 and the chi-square test-of-fit give an indication of how well the model fits the data. R_L^2 of 0.88 for ERC(G) indicates a better fit than the

Table 6—Summary statistics for the logistic regression curves shown in figure 15.

Explanatory variable	Model probability range	Observed fraction range	SSR(1)	p-value	R_L^2	chi-sq (8 df)	p-value
ERC(G)	.04 - .95	.02 - .73	1981.6	.0000	.88	143.6	.0000
BI(C)	.27 - .47	.15 - .38	59.9	.0000	.22	110.7	.0000

R_L^2 of 0.22 for BI(C); but the chi-square test of fit indicates that neither is a good fit. One should use all information available to choose between two logistic regression models. Some of this information is statistical, some visual, and some common sense. More discussion on this topic appears in the "Choice of Index and Fuel Model" section.

Percentiles and Probabilities—a Comparison

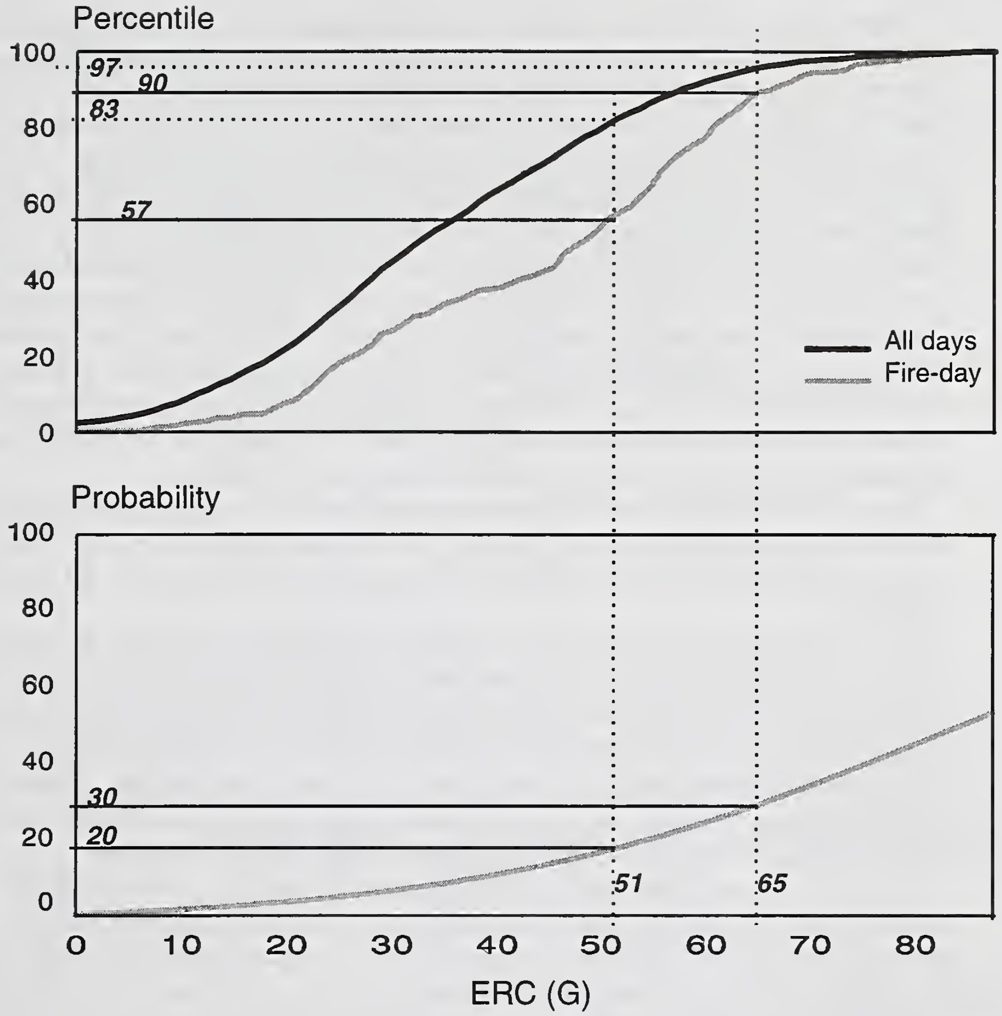
Significant differences exist between interpretation of the percentile and the probability curves. Because of their similar appearance and even similar names, we take some extra time to compare and describe them. Figure 16 shows percentile and probability curves for the same set of data— Mammoth weather station in Yellowstone National Park.

Percentiles are merely the result of counting where the data lie and then converting to percentages. Percentiles, by definition, always go from 0 to 100 percent. In this example, the 97th percentile of all-days is ERC = 65; that means that 3 percent of the ERC values are above 65. The 83rd percentile is 51. And 14 percent (97 – 83 = 14) of the ERC values are from 51 and 65 (between the 83rd and 97th percentile levels). Also, 33 percent of the fire-days occurred on days of ERC from 51 to 65. The probability that a day with ERC of 51 will be a fire-day is 20 percent; the probability of a fire-day for ERC of 65 is 30 percent. Percentile values are meaningful for index ranges, as the percentage of the days above a value, or between two values; while a probability value is given for a specific index value.

Setting Fire Danger Levels

The continuum of fire danger is often divided into discrete classes to which preplanned management actions are keyed. The designations for the classes are commonly low, moderate, high, very high, and extreme. A critical value is sometimes defined, above which a different management action or decision is made. The level of fire danger is used, for example, to identify the need for forest closure, aid in wildfire/prescribed natural fire decisions, set dispatch level, and implement logging restrictions.

Fire danger levels are generally based only on information from historical fire danger values. One method of setting decision points involves using the 90th and 97th percentile levels as in figure 13. (The BLM uses the 80th and 95th percentile levels.) FIRES allows information on historical fire activity to be used in addition to historical index data. Consideration of the relationship of indexes to historical fire occurrence and size makes it possible to better set fire danger levels for a variety of fire management needs.



ERC	Percentile	Probability of a Fire-day	ERC Range	Percent of Days	Percent of Fire-days	Probability of a Fire-day
			0-18	20	5	0-5
18	20	5	19-35	37	27	5-10
35	57	10	36-50	26	25	10-20
51	83	20	51-65	14	33	20-30
65	97	30	66+	3	10	30-60
			all	100	100	

Figure 16—Percentile and probability curves and data tables for selected ranges for Yellowstone National Park, Mammoth weather station.

The section of FIRES designed for this purpose is reached through **View | Decision Points**. Percentile and probability curves for the selected index are plotted and displayed along with default fire danger levels based on the 90th and 97th percentile values. The curves with cutoff lines are on the left side of the screen. On the right half are displayed five bar graphs that plot relative frequency of fires by fire danger level for all-days, fire-days, large-fire-days, and multiple-fire-days. In the lower right corner, fire danger class break points are displayed and may be edited by typing the desired number over the highlighted value. **Tab** or **Enter** moves the cursor between classes. Pressing **F1** executes the changes and redraws the graphs. The number of classes can be changed by entering a value for a class that is less than the value of the next lower class; for example, entering a value under class 4 that is less than the value under class 3 results in three fire danger classes. **Escape** (Esc) returns the bar menu to the top of the screen.

Plate 7 shows the default classes according to the suggested method described in connection with figure 11. Figure 17a shows the effect of changing the lower ERC value for each class from 0, 20, 40, 81, 85 to 0, 30, 50, 70, 80.

Figure 17b shows the result of setting a single cutoff point for the Mt. Pleasant weather station on the Tonto National Forest in Arizona. Half of the days fall below ERC = 33, but only 19 percent of the fire-days, 4 percent of the large-fire-days, and 4 percent of the multiple-fire-days fall below that value. Saying the same thing another way: Half of all-days had an ERC 33 or more, but 81 percent of the fire-days, 96 percent of the large-fire-days, and 96 percent of the multiple-fire-days occurred when ERC 33 or more.

A table of values is available for the intervals that have been set. Look, for example, at figure 17a. The upper part of the table gives tallies and percentages taken from the percentile curves in the upper left plot. The lower part of the table gives probability values for each interval as calculated from the logistic regression model; the probability curves are shown in the lower left plot. For ERC of 80 to 97 (class 5), there were 457 days, 209 fire-days, 22 large-fire-days, and 19 multiple-fire-days. Of all-days, 15 percent fell in class 5 (457/2980 = 15 percent), while 46 percent of the large-fire-days fell in that class (22/48 = 46 percent). Of the 457 days in class 5, 4 percent of them were large-fire-days (22/457 = 4 percent). Note that the 209 fire-days in class 5 amounted to 45 percent of the days in that class (209/457 = 45 percent), but the 329 fire-days in class 3 (ERC of 50 to 69) were 34 percent of the days in that class (329/946 = 34 percent).

Choice of Index and Fuel Model

FIRES offers methods for looking at indexes as they relate to fire activity as a way to choose an appropriate index and fuel model. This is an alternative to the subjective methods that are often used. Burning Index is sometimes chosen because of its association with flame length (although there is a relationship based on the equations that are used, BI is not flame length). Similarly ERC is sometimes avoided because it is associated with heat per unit area, something that is not as easily visualized as flame length. And understandably, fuel model is often chosen according to a vegetation name that has been associated with it, rather than by the components that make up the fuel model (see table 1).

(a)

Class Data From : C:\FIRES\DATA\MT_ELIZ.ANA (7G3PD3)
Index Variable is: ERC
Cause = All   Large = 10+   Multi = 5+

Percentages Based On Current Class Definitions
(* denotes column is in bar chart)

Cls	Index	All-Days		--Fire-Days--			-Large-Fire-Days-				-Multi-Fire-Days-			
#	Range	#	%*	#	%FD*	%AD	#	%LFD*	%FD	%AD	#	%MFD*	%FD	%AD
1	0- 29	274	9	48	5	17	0	0	0	0	2	3	4	0
2	30- 49	597	20	148	14	24	1	2	0	0	4	6	2	0
3	50- 69	946	32	329	32	34	10	21	3	1	22	32	6	2
4	70- 79	706	24	297	29	42	15	31	5	2	22	32	7	3
5	80- 97	457	15	209	20	45	22	46	10	4	19	28	9	4
		2980	100	1031	100		48	100			69	100		

Model Probabilities (%)

Cls #	Index Range	Fire Day	Large F-Day	Multi F-Day
1	0- 29	12- 20	0- 0	0- 1
2	30- 49	21- 29	0- 0	1- 2
3	50- 69	29- 39	0- 2	2- 3
4	70- 79	39- 44	2- 3	3- 3
5	80- 97	45- 55	3- 9	4- 6

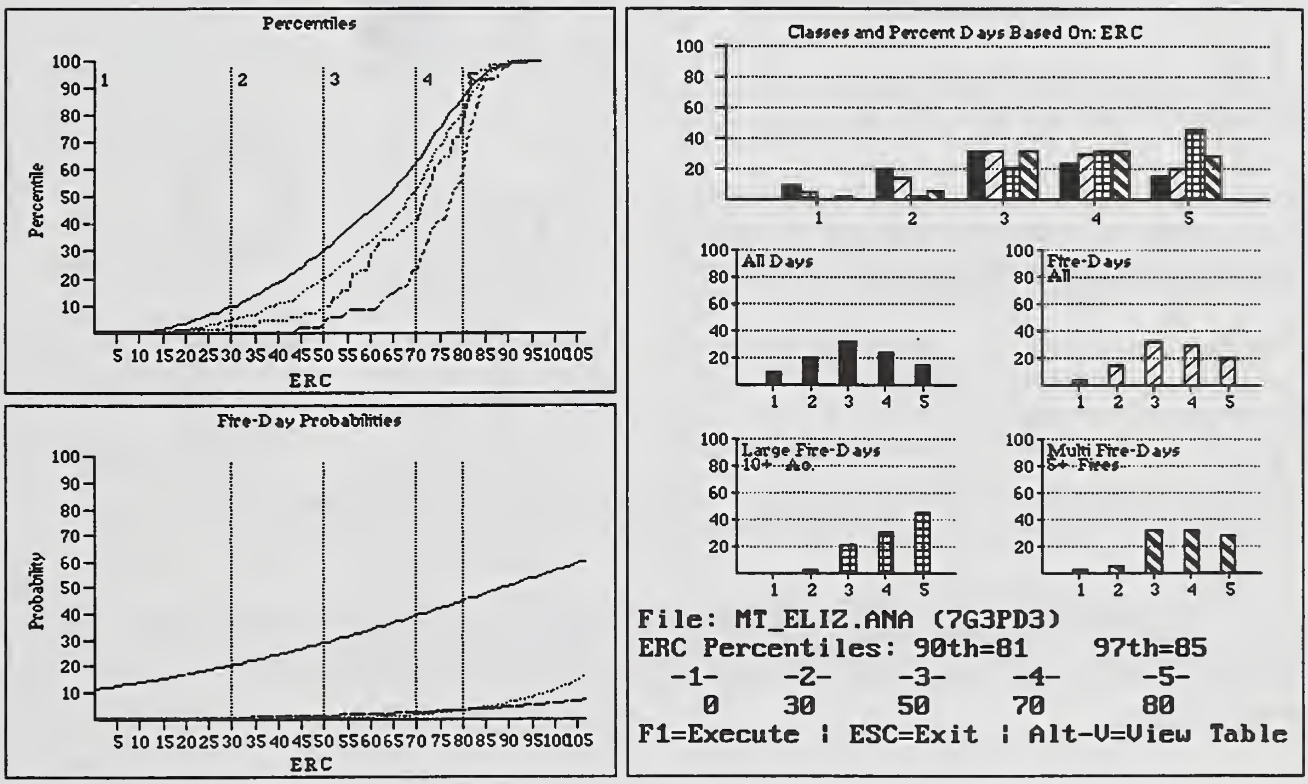


Figure 17—Decision level screen. See defaults in color plate 7. (a) Same as plate 8, but with different levels. (b) Two levels.

(b) Class Data From : C:\FIRES\DATA\ARIZONA\AZ_7494G.ANA (7G5PD2)
Index Variable is: ERC
Cause = All Large = 10+ Multi = 5+

Percentages Based On Current Class Definitions
(* denotes column is in bar chart)

Cls #	Index Range	All-Days #	All-Days % *	Fire-Days #	Fire-Days %FD *	Fire-Days %AD	Large-Fire-Days #	Large-Fire-Days %LFD *	Large-Fire-Days %FD	Large-Fire-Days %AD	Multi-Fire-Days #	Multi-Fire-Days %MFD *	Multi-Fire-Days %FD	Multi-Fire-Days %AD
1	0- 32	3822	51	478	19	12	21	5	4	0	12	4	2	0
2	33- 91	3688	49	2082	81	56	409	95	19	11	258	96	12	6
		7510	100	2560	100		430	100			270	100		

Model Probabilities (%)

Cls #	Index Range	Fire Day	Large F-Day	Multi F-Day
1	0- 32	4- 27	0- 3	0- 2
2	33- 91	29- 95	3- 53	2- 37

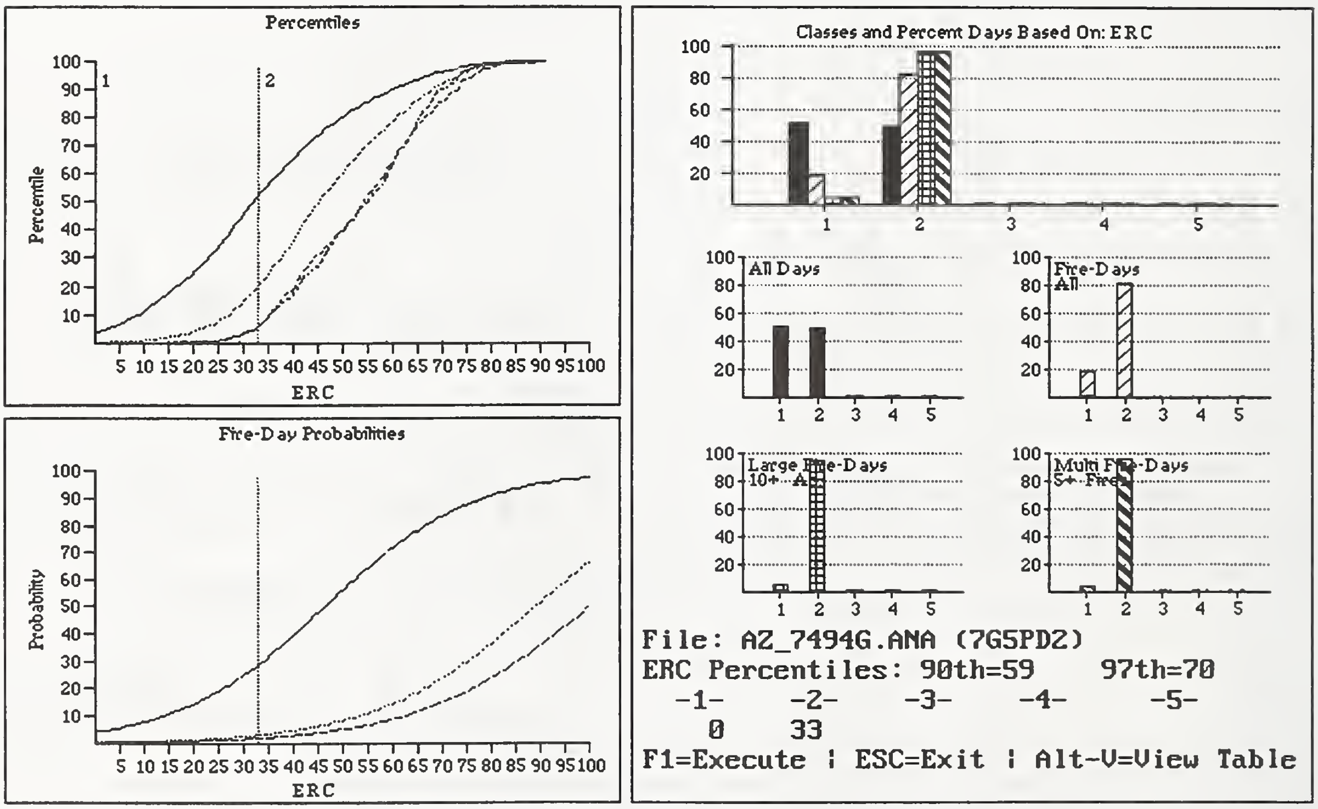


Figure 17—(Con.)

Following are some steps to take in choosing the most appropriate fire danger index and fuel model:

- Look at the fuel model table (table 1). Choose models that best reflect the fuels as they react to weather changes.

  A, L—Have only fine dead fuel and will react quickly to weather changes.

  A, L, N, C, D, T—Have no 100 h or 1,000 h fuels. Note in figure 3 that max/min temperature and relative humidity and precipitation duration are therefore not included in the calculations of dead fuel moisture and that there is no carryover from the previous day's fire danger rating except for live fuel moisture. Calculations are based only on each day's afternoon weather reading.

  I, J, K, H, G—Have 1,000 h fuel that reflects long-term drying.

- Calculate fire danger indexes for several fuel models for comparison. Look at the seasonal plot of maximum and average for the index. Does it match your perception of "fire season" for the area? For example, low in spring and fall and higher in the summer in the Northwestern United States.
- Look at seasonal plots for each year in the data base. Don't limit yourself to 10 years; use all that you have (assuming they are quality data). Is the change from year to year reflected by the index? Look at several indexes for each fuel model.
- Look at seasonal plots of the index along with fire-days, large-fire-days, and multiple-fire-days. Is fire activity happening on the higher index days?
- Compare the all-days percentile curve to those for fire-days, large-fire-days, and multiple-fire-days. Is there a difference? Is the fire activity happening on the higher index days? Are there low index days with no fire activity?
- Look at the probability curves that come from the logistic regression analysis. Is the probability of a fire-day near zero at low indexes and quite a bit higher at high indexes? Is the probability of large-fire-days and multiple-fire-days near zero for low index days?
- Look at the statistical measures of test of fit. Compare the results from several indexes as described in the "Probabilities and Logistic Regression" section.

Remember the purpose and philosophy of fire danger rating in choosing the best fire danger indicator. We suggest that the value of a fire danger index be assessed with respect to its relationship to fire activity and its success in tracking the fire season.

Discussion

We see opportunities for improvement of the FIRES program, expansion of its capabilities, and integration with other systems. The discussion of the many related fire danger programs (see fig. 4 and table 2) makes it clear that

there is work to be done on integrating programs, systems, and data bases. The outdated nature of the current situation also shows up in appendix C, in which there is reference to columns on 80-column cards where the data were once punched. Younger readers likely won't even know what a computer punch card looks like. Features in FIRES such as printer drivers and graphics could be improved. The large memory requirement could be resolved, and FIRES could be made Windows-compatible. It would also be desirable, for example, to allow an easy integration of daily fire danger calculations from PCDANGER, historical calculations from FIRDAT, and calculations based on weather scenarios into the future. At the time of this writing, work to resolve deficiencies and to make improvements is in fact progressing under the working name "Firefamily Plus."

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Appendix A: Setup and Installation

System Requirements

The FIRES program requires minimal personal computer hardware (but it does require a lot of memory). It is self-contained in that it doesn't require separate statistics or graphics software. The hardware requirements are as follows:

CPU:	386 with math coprocessor or better.
Hard Drive:	4 megabytes of free disk space. (1 MB for program and support files and 3 MB for sample data files.)
RAM:	550 kb of free RAM. FIRES does not use extended or expanded memory. You may need to load DOS and system devices in high memory by using the DOS MEMMAKE utility. On laptops with PCMCIA cards, the card drivers usually take up quite a lot of low memory, which leave FIRES crippled for doing the logistic regressions. Often, these machines come with a start-up menu that allows you to bypass the installation of the PCMCIA drivers. You should do this if running FIRES on a laptop with this option.
Monitor:	Color VGA.
Printer:	Optional. FIRES uses archaic drivers for its graphics printing. As a result, there is fairly limited printer support, particularly for color printers. We have had good results using most screen grab utilities to print color plates. Also, when running FIRES in the Windows environment, using the Print Screen key to capture the screen image to a bitmap file in the clip board also works well.

Suggested Directory Setup

We suggest that you use the directory name "FIRES" for program files and create subdirectories for your own data files. You might consider a separate data subdirectoy for each analysis area's index, fire occurrence, and analysis files. A typical directory structure for this type of installation is shown in figure A-1.

Figure A-1—Example directory structure for the FIRES program and related data files.

```
 Directory of C:\FIRES

.            <DIR>     12-10-96   4:06p
..           <DIR>     12-10-96   4:06p
FIRES        <DIR>     12-10-96   4:06p  Subdirectory for FIRES program and example data files.
LOLO_NF      <DIR>     12-10-96   4:06p  Data files for Lolo analysis area (*.PSF, *.ANA, *.FPL).
KOOTENAI     <DIR>     12-10-96   4:06p  Data files for Kootenai analysis area (*.PSF, *.ANA, *.FPL).
```

Alternatively, if you already have a “FIRFAMLY” subdirectory on your computer, it is convenient to make FIRES a subdirectory of FIRFAMLY. This makes it easy to navigate to PCFIRDAT generated passing files. In this case you could also create a subdirectory for fire occurrence files (for example, FIRE_OCC). A typical directory structure for this type of installation is shown in figure A-2.

Installation Procedure

The following is an example of how you might do the installation in DOS. Bold type indicates your key entries, regular type indicates the DOS prompts. You may use the Windows File Manager to do the equivalent in Windows.

At the DOS prompt create a directory on the hard drive and move to that directory.

C:**cd **
C:\>**md \FIRES**
C:\>**cd \FIRES**
C:\FIRES>

To do this under the FIRFAMLY directory the following commands would be used:

C:**cd \FIRFAMLY**
C:\FIRFAMLY>**md FIRES**
C:\FIRFAMLY>**cd FIRES**
C:\FIRFAMLY\FIRES>

Copy the self-extracting distribution file, FIRE_SEN.EXE, from the diskette to the FIRES directory (directory could be \FIRFAMLY\FIRES).

C:\FIRES>**copy a:\FIRES\FIRE_SEN.EXE**

Expand the distribution file

C:\FIRES>**FIRE_SEN**

If you wish, you may delete FIRE_SEN.EXE

C:\FIRES>**del FIRE_SEN.EXE**

Figure A-2—Directory structure where FIRES and other NFDRS programs are set up as subdirectories of FIRFAMLY.

```
 Directory of C:\FIRFAMLY

.            <DIR>       12-10-96   4:06p
..           <DIR>       12-10-96   4:06p
FIRES        <DIR>       12-10-96   4:06p   Subdirectory for FIRES program and example data files.
FIRE_OCC     <DIR>       12-10-96   4:06p   Subdirectory for fire occurrence (*.FPL) files.
FWXDATA      <DIR>       12-10-96   4:06p   Subdirectory for NIFMID Fire Weather (*.FWX) files.
OUTFILE      <DIR>       12-10-96   4:07p   Subdirectory for PCFIRDAT output (*.OUT) files.
PASSFILE     <DIR>       12-10-96   4:06p   Subdirectory for PCFIRDAT passing (index) (*.PSF) files.
PCFIRDAT     <DIR>       12-10-96   4:06p   Subdirectory for PCFIRDAT program files.
PCSEASON     <DIR>       12-10-96   4:06p   Subdirectory for PCSEASON program files.
```

Running the Program

To start the program from DOS, move the appropriate directory and type FIRES.

C:\>**cd \FIRES**
C:\FIRES>**FIRES**

Although FIRES is not a Windows program, it can be run from Windows as a DOS application. Because of the graphics, however, you must run it as a full screen (not windowed) application in Windows 3.x. Windows 95 allows a windowed application.

When FIRES initiates, there will be a number in the top right corner of the screen. This indicates the amount of low memory available to FIRES for calling the logistic regression and sort programs. This number must be more than 75000, preferably about 140000. The program will check for available memory and provide messages as appropriate.

Printer Setup

To define a printer driver for your analysis output, go into **Utilities** from the FIRES main menu (arrow key over and press enter or type U). Select **Define Printer** to access the printer definition screen. **Alt-H** will access a help screen with a list of printer drivers from which to select. Find the printer code that most closely matches your printer (for example, -22 for an HP LaserJet); enter that code in the driver box. Then enter the correct code for your printer port. You may also chose to have the output routed to a print file instead of the printer. This filename will always be FILEOUT.PRN, which can be printed with the DOS command:

Copy/b fileout.prn lpt1

where the /b switch indicates a binary file, and lpt1 is the printer port.

As mentioned in the help screen, higher resolution drivers take much longer to print with no appreciable improvement in print quality. We highly recommend that you stick with the lower density drivers.

Sample Data Files

Three sample data sets are included in the distribution file, FIRE_SEN.EXE. They include the fire occurrence file (*.FPL), the weather/index passing file (*.PSF), and the analysis file (*.ANA) for three locations:

Black Creek National Forest, Mississippi, 1974-1994
All fires, Black Creek National Forest
Black Creek weather station, year-round data
BC_7494.FPL, BLACK_CR.PSF, BC_7494.ANA

Superior National Forest, Minnesota, 1986-1992
Fires within the Boundary Waters Canoe Area Wilderness
Seagull weather station May through October data
BOUNDARY.FPL, SEAGULL.PSF, BDR8692.ANA

Kootenai National Forest, Montana, 1980-1994
All Kootenai National Forest fires
Libby weather station, May through October data
KOOT8094.FPL, LIBBY.PSF, KOOT8094.ANA

Appendix B: Sample FIRES Run

The following sample run takes you into the FIRES program just enough to get you going—to load files, to display fire summaries, seasonal plots, percentile and probability curves, and to set decision points. We give step by step operating instructions noting what you should see on the screen. This is written under the assumption that you will go through the whole thing; there is carryover from one step to the next. The files referenced here are included as examples with the program.

Don't use the mouse. To make selections from menus, type the first letter of the choice or use arrow keys and Enter. "Edit keys" refers to the arrow keys, page up, and page down.

Open a fire file:

Select **File** from the Main menu.
Select **Open** from the File menu.
Select **Fire** from the Open menu.
Select **KOOT8094.FPL** from the list of files.
Select **KCC_FPL.DEF** from the list of format definition files.
Note that the fire file name is saved on the screen.
Esc Esc to get back to the Main menu.

View a summary of the fire data:

Select **View** from the Main menu.
Select **Fires** from the View menu.
The display will show five bar graphs, similar to color plate 1.
Note that the file name is at the top left of the screen.
Select **Table** from the Graph menu.
The display will show the data that were used to produce the charts.
Use the edit keys (arrows, page up, and so on) to move through the document.
Esc Esc Esc to get back to the Main menu.

Open an analysis file:

Select **File** from the Main menu.
Select **Open** from the File menu.
Select **Analysis** from the Open menu.
Select **KOOT8094.ANA** from the list of files.
Select **FIRDAT.DEA** from the list of format definition files.
Note the file names are saved on the screen.
Esc Esc to get back to the Main menu.

View seasonal plots:

Select **View** from the Main menu.
Select **Indexes & Fire Days** from the View menu.
Select **Season Plots** from the Indexes menu.
Select **All Years** from the Season menu.
Use the edit keys to highlight **Temperature** on the variable list.
Hit the **Space Bar** to choose Temperature.

Use the edit keys to highlight **Burning Index** on the variable list.
Hit the **Space Bar** to choose Burning Index.
Hit **Enter** to begin processing.
Choose **Y** for "plot historical daily maximum on each graph?"
Choose **N** for "daily average" and "daily minimum."
Hit **F1** to begin plotting.
The six seasonal plots per screen will look similar to color plate 2.
Hit **Enter** or any key to move through all of the plots for Temperature and Burning Index.
Select **Selected Years** from the Season menu.
Use edit keys to move to **Temperature** on the variable list.
Hit the **Space Bar** to de-select Temperature.
Burning Index is still selected.
Hit **Enter** to begin processing.
Type **93-94** as the years to plot. Hit **Enter**.
Hit **Enter** for **Y** in answer to all questions.
The graph looks similar to color plate 3.
Select **Next** from the graph menu to return to the Season menu.

Select **Selected Indexes** from the Season menu.
Use the edit keys to move to **Burning Index** on the variable list.
Hit the **Space Bar** to de-select Burning Index.
Select **Energy Release Component** and **Keetch Byram Drought Index** from the variable list using edit keys and the space bar.
Hit **Enter** to begin processing.
Type **90-94** as the years to plot. Hit **Enter**.
Enter selects **Next** to produce the plots for those years.

View percentile plots:
Esc to go back to Index menu.
Select **Percentiles** from the Index menu.
De-select Keetch Byram Drought Index from the variable list using edit keys and space bar.
Enter produces a plot similar to color plate 5.
Enter selects **Next** to return to the Index menu.

View probability plots:
Select **Probabilities** from the Index menu.
Hit **Enter** to use the current variable **Energy Release Component** from the list.
Statistics information scrolls by on the screen as the logistic regression is done.
A plot similar to color plate 6 is produced.
Select **Table** from the Graph menu (or type **T**).
A table similar to figure 19a is displayed.
Use the edit keys to view the rest of the table.
Esc to view a table of the values used to plot the probability curves.
Esc to return to the Graph menu.
Enter selects **Next** to return to the Index menu.
Esc to return to the View menu.

View and redefine decision points:

Select **Decision Points** from the View menu.

Hit **Enter** to use the current variable **Energy Release Component** from the list.

Statistics information scrolls by on the screen as the logistic regression is done.

A screen similar to color plate 7 is produced.

Type **20** and **Enter** to replace the highlighted 10 with 20.

Type **30** and **Enter** to replace the highlighted 20 with 30.

Type **40** and **Enter** to replace the highlighted 41 with 40.

Hit **F1** to change the decision points and redraw the bar graphs.

Push **Alt-V** to view the table of values that goes with the chosen classes.

Esc to go back to the interactive decision point screen.

Esc to get back to the Graph menu.

Enter to choose Next to go back to the View menu.

Esc to go back to the Main menu.

Type **Q** for Quit to terminate the FIRES run.

Appendix C: Data Files

The primary file types used by the FIRES program are given in table 5 and the information flow is diagrammed in figure 4. Although most users will need only that much information, a complete list of file types (table C-1), file

Table C-1—File types used by the FIRES program.

File Extension	File Contents and Description
*.FPL	Fire occurrence file.
*.DEF	Fire occurrence definition file.
*.PSF	Index file; "passing" file.
*.DEI	Index definition file.
*.ANA	Analysis file.
*.DEA	Analysis definition file.
*.FWX	Weather file, input to FIRDAT
*.SRT	Sort command file for sorting non-standard fire file by date (yymmdd).
*.CMD	Sort command file for sorting standard (NFMAS) fire file by date (yymmdd).
*.SUM	Session summary of goodness-of-fit statistics.
*.HLP	FIRES Help file.
*.STR	DBASE structure definitions.
*.TBL	Probability goodness-of-fit tables.
*.PRB	Exported graph data from **View | Index | Probabilities.**
*.PTL	Exported graph data from **View | Index | Percentiles.**
*.OCC	Exported graph data from **View | Fires.**
*.VAR	Exported graph data from **View | Indexes | Season | Selected Years** where VAR is the currently viewed variable (for example, ERC)
*.YR	Exported graph data from **View | Indexes | Season | Selected Indexes** where YR is the currently viewed year (for example, 88).
*.DEC	Exported graph data from **View | Decision Points**
*.FON	Graphic Fonts
*.LOG	Analysis file preparation process log.

formats, and detailed information on definition and analysis files is given here for completeness.

The format of the fire occurrence file (*.FPL) from NIFMID (used by the Forest Service) is given in table C-2. The U.S. Department of the Interior format for data stored in the Shared Applications Computer System (SACS) is given in table C-3. The codes for final fire size and cause are given in tables C-4 and C-5.

The "short" format for a NIFMID fire weather file (*.FWX) is given in table C-6. Table C-7 gives the format for the information that is used in calculating NFDRS values. This is referred to as "header record" or "lead card" data. Columns 1 through 99 of table C-8 is the resulting "passing file" (*.PSF) of weather and NFDRS values that is produced by either the FIRDAT or PCFIRDAT program. The data in columns 100 through 127 are added when the fire file (*.FPL) is merged with the index file (*.PSF) creating an analysis file (*.ANA).

The formats are described for the FIRES program by means of definition files. We describe here details of the analysis file (*.ANA) and its definition file (*.DEA). The listing of the FIRDAT.DEA file in figure C-1 illustrates the file structure. Lines starting with [fires] are headers that define some things about the file. Following the header records there is a line for every variable in the file, with eight fields per line. These fields define the variable number, long and abbreviated names, variable type, field length and number of decimals, graph type, and interpolation method. The FIRES program reads this file to construct input formats and the variable names and abbreviations that appear in program pick-lists and graphic outputs.

Figure C-2 contains several records taken from the example analysis file, BOUNDARY.ANA. It also has a header structure designated by the [fires] sequence. The header structure contains the *.DEA file needed to read the analysis file, a comment on the contents of the analysis file, and the passing file header information as described in table C-3, modified to describe the cause classes and the large- and multiple-fire-day thresholds used to build the file. The first record in the file below describes May 20th, 1990 (90 520). It was a fire-day with one fire, zero acres. May 27th (90 0527) also was a fire-day, but was a large-fire-day with 315 acres. Additionally, as denoted by the 6 in the missing day column, May 27 was the 5th day in a string of 6 days of missing weather. The weather and indexes for those days were interpolated as defined in the FIRDAT.DEA file.

Table C-2—Fire occurrence NIFMID NFMAS (*.FPL) file format description (KCC_FPL.DEF), used by USDA Forest Service.

Field Description	Begin	End
Reporting Region and Forest (RRFF)	1	4
Fire Number	5	8
Discovery date (YYMMDD)	9	14
Discovery hour	15	16
Location	17	26
Statistical cause		27
General cause	28	29
Specific cause	30	31
Class of people		32
Fire size class		33
Total area burned (whole acres)	34	40
Cost class		41
Vegetation cover type at origin	42	43
Fuel type at origin (not NFDRS)	44	49
blank	50	55
FS-5100-29 slope class		56
NFDRS slope class		57
NFMAS aspect		58
Elevation class		59
Topography code.		60
Fire Mgmt Analysis Zone	61	65
Fire weather station number	66	71
First NFDRS fuel model.		72
Percent area covered by first fuel model.	73	74
Second NFDRS fuel model.		75
Percent area covered by second fuel model.	76	77
Herbaceous vegetation type		78
Fire Intensity Level from NIFMID		79
Calculated FIL		80

Table C-3—Fire occurrence SACS (*.FPL) file format description (DOI_FIRE.DEF), used by agencies within the U.S. Department of the Interior.

Field Description	Begin	End
Discovery year	1	2
Discovery month	3	4
Discovery day	5	6
Statistical cause class		7
Size class		8
Final fire size, acres	9	15

Table C-4—Fire final size class codes.

Fire Size Class Code		Final Fire Size, acres
A	1	<¼
B	2	¼ - 9
C	3	10 - 99
D	4	100 - 299
E	5	300 - 9999
F	6	1000 - 4999
G	7	5000+

Table C-5—Statistical cause codes.

Cause Class Code	Fire Cause
1	Lightning
2	Equipment
3	Smoking
4	Campfire
5	Debris Burning
6	Railroad
7	Arson
8	Children
9	Miscellaneous

Table C-6—Fire weather observation (*.FWX), NIFMID standard "short" format.

Field Description	Begin	End
Station Number	1	6
Year	7	8
Month	9	10
Day	11	12
State of Weather (code)		13
Dry Bulb Temperature (°F)	14	16
Relative Humidity (%)	17	19
Herbaceous Greenness Factor	20	22
Herbaceous Vegetation Condition	23	24
Human-Caused Risk	25	27
Wind Direction (8 point)		28
Wind Speed (mph)	29	31
Woody Vegetation Condition		32
10-hr Fuel Moisture (%)	33	35
Woody Greenness Factor	36	38
Maximum Temperature (°F)	39	41
Minimum Temperature (°F)	42	41
Maximum Relative Humidity (%)	45	47
Minimum Relative Humidity (%)	48	50
Season Code		51
Precipitation Duration (hr)	52	53
Precipitation Amount (in)	54	57
Lightning Activity Level	58	60
Relative Humidity Variable 1 = wet bulb, 2 = RH, 3 = dew pt		61
Forecast Flag		79
Region Number		80

Table C-7—"Header record" or "lead card" information used to create the "passing file" of weather and index data.

Field Description	Begin	End
Header records follow one of the following separator records: 999999999999 if from FIRDAT at NCC-KC 888888888888 if from PCFIRDAT 888888 if from PCFIRDAT, RERAP query		
Station Owner	1	12
Station Name	13	32
Station Number	33	38
Station Elevation	39	43
Station Latitude	45	46
NFDRS Fuel Model System (7=78, 8=88)		47
NFDRS Fuel Model (A-U, not M)		48
NFDRS Slope Class (1-5)		49
Herbaceous Type (A=Annual, P=Perennial)		50
Shrub Type (E=Evergreen, D=Deciduous)		51
NFDRS Climate Class (1-4)		52
The above NFDRS parameters are often shown on FIRES graphs and tables in a terse format, such as "7D1PD3" where each numeral or character stands for an NFDRS parameter. In this example; 7 indicates the 1978 fuel model system, D refers to NFDRS fuel model, 1 refers to the slope class, P indicates that grass type is perennial, D indicates that shrubs are deciduous, and 3 indicates that the station is located in climate class 3.		
Run Date	56	67
Start Year	70	71
End Year	72	73

Table C-8—Weather and index "passing" file (*.PSF) created by FIRDATor PCFIRDAT (FIRDAT.DEI). Information added to make this an ANALYSIS file (*.ANA) is described at the bottom of the table (*.DEA).

Field Description	Begin	End
Station ID	1	6
Year	7	8
Month	9	10
Day	11	12
Julian Date	13	15
Processing Option		16
State of Weather		17
Temperature, F	18	20
Relative Humidity, %	21	23
Wind Direction, 8 Pt		24
Wind Speed, mph	25	27
Maximum Temperature, F	28	30
Minimum Temperature, F	31	33
Maximum Humidity, %	34	36
Minimum Humidity, %	37	39
Precipitation Duration, hr	40	41
Precipitation Amount, hundredths, (no decimal. 0025 = 0.25)	42	45
Lightning Activity Level		46
Human-Caused Risk	47	49
1-hr Fuel Moisture, % (10ths, no decimal. 045 = 4.5%)	50	52
10-hr Fuel Moisture, % (10ths, no decimal. 100 = 10.0%)	53	55
100-hr Fuel Moisture, % (10ths, no decimal. 154 = 15.4%)	56	58

Field Description	Begin	End
1000-hr Fuel Moisture, % (10ths, no decimal 356 = 35.6%)	59	61
Woody Fuel Moisture, % (Whole percent 088 = 88%)	62	64
Herbaceous Fuel Moisture, % (Whole percent, 250 = 250%)	65	67
Ignition Component	68	72
Spread Component	73	75
Energy Release Component	76	78
Human Occurrence Index	79	81
Lightning Occurrence Index	82	84
Burning Index	85	87
Fire Load Index	88	90
Keetch Byram Drought Index	91	93
Herb Greenness Factor	94	96
Woody Greenness Factor	97	99
The following fields are added by FIRES to create an ANALYSIS file.		
Missing Weather Run Indicator	100	102
Fire-Day Flag (0/1)		105
Total Fires	106	108
Large-Fire-Day Flag (0/1)		111
Total Large Fires	112	114
Multiple-Fire-Day Flag (0/1)		117
Total Acres from fires discovered today	118	127

Figure C-1—Listing of FIRDAT.DEA, the file that defines the information in the analysis file.

```
[fires] dea filename=FIRDAT.DEA
[fires] comment=Definition File for FIRDAT/PCFIRDAT Analysis File
1,'Station','Stn','A',6,0,'Bar','P'
2,'Year','YR','N',2,0,'Bar','P'
3,'Month','Month','N',2,0,'Bar','P'
4,'Day','Day','N',2,0,'Bar','I'
5,'Julian Date','Jdate','N',3,0,'Bar','I'
6,'Processing Option','Opt','N',1,0,'Bar','P'
7,'State of Weather','SW','N',1,0,'Bar','P'
8,'Temperature','Temp','N',3,0,'Line','I'
9,'Relative Humidity','RH','N',3,0,'Line','I'
10,'Wind Direction','WD','N',1,0,'Bar','P'
12,'Wind Speed','WS','N',3,0,'Line','P'
12,'Max Temperature','Max_Temp','N',3,0,'Line','I'
13,'Min Temperature','Min_Temp','N',3,0,'Line','I'
14,'Max Relative Humidity','Max_RH','N',3,0,'Line','I'
15,'Min Relative Humidity','Min_RH','N',3,0,'Line','I'
16,'Precipitation Duration','Ppt_Dur','N',2,0,'Bar','0'
17,'Precipitation Amount','Ppt_Amt','N',4,2,'Bar','0'
18,'Lightning Activity Level','LAL','N',1,0,'Bar','P'
19,'Human-Caused Risk','HCR','N',3,0,'Line','P'
20,'1-Hour Fuel Moisture','FM1','N',3,1,'Line','I'
21,'10-Hour Fuel Moisture','FM10','N',3,1,'Line','I'
22,'100-Hour Fuel Moisture','FM100','N',3,1,'Line','I'
23,'1000-Hour Fuel Moisture','FM1000','N',3,1,'Line','I'
24,'Woody Moisture','FM_Woody','N',3,0,'Line','I'
25,'Herbaceous Moisture','FM_Herb','N',3,0,'Line','I'
26,'Ignition Component','IC','N',5,0,'Line','I'
27,'Spread Component','SC','N',3,0,'Line','I'
28,'Energy Release Component','ERC','N',3,0,'Line','I'
29,'Human Occurrence Index','HCOI','N',3,0,'Line','I'
30,'Lightning Occurrence Index','LOI','N',3,0,'Line','I'
31,'Burning Index','BI','N',3,0,'Line','I'
32,'Fire Load Index','FLI','N',3,0,'Line','I'
33,'Keetch-Byram Index','KBDI','N',3,0,'Line','I'
34,'Herb Greenness Factor','HGF','N',3,0,'Line','P'
35,'Woody Greenness Factor','WGF','N',3,0,'Line','P'
36,'Missing Weather','Miss_Wx','N',3,0,'Bar','0'
37,'Fire Day','FD','N',3,0,'Bar','0'
38,'Total Fires','Fires','N',3,0,'Bar','0'
39,'Large Fire Day','LFD','N',3,0,'Bar','0'
40,'Total Large Fires','Lar_Fires','N',3,0,'Bar','0'
41,'Multiple Fire Day','MFD','N',3,0,'Bar','0'
42,'Total Acres This Day','Acres','N',10,0,'Bar','0'
```

Figure C-2—Example records from an analysis file (BOUNDARY.ANA).

```
[fires] dea filename=C:\LARRY\FIRES\FIRDAT.DEA
[fires] comment=Boundary Waters Wilderness Fires, Seagull FWX
USFS       SEAGULL           210709 1480 487G1PD3105MAR  9, 19952588692     Cause = All         Large = 10+    Multi = 5+


21070990 52014010 58 485  6 60 25100 47 0   01  6 90170178267174181    8  3  9  0  0 13  9  5  0  0  0  1  1  0  0  0          0
21070990 52114113 60 404  7 64 28100 35 0   01  4 96170167252200193    6  3 12  0  0 16 11  8  0  0  0  0  0  0  0  0          0
21070990 52214213 60 545  8 63 36100 48 0   01  5118180163248199205    4  3 12  0  0 16 11 11  0  0  0  0  0  0  0  0          0
21070990 52314313 61 515  8 64 34100 45 0   01  5110170160250199206    5  3 13  0  0 16 11 12  0  0  6  0  0  0  0  0          0
21070990 52414413 61 485  8 65 33100 42 0   01  5100170160250198208    5  3 13  0  0 15 11 12  0  0  6  0  0  0  0  0          0
21070990 52514513 62 455  8 66 31100 39 0   01  5100160160250198209    6  3 14  0  0 15 11 13  0  0  6  0  0  0  0  0          0
21070990 52614613 62 415  8 66 30100 35 0   01  5 90160160250197210    7  2 14  1  0 15 10 14  0  0  6  0  0  0  0  0          0
21070990 52714713 63 385  8 67 28100 32 0   01  5 80150160250197211    8  2 15  1  0 15 10 15  0  0  6  1  1  1  1  0        315
21070990 52814813 63 355  8 68 27100 29 0   01  5 80150160250196213    8  2 15  1  0 14 10 15  0  0  6  0  0  0  0  0          0
21070990 52914911 64 328  4 69 25100 26 0   01  6 70140153245196214    9  2 16  1  0 14 10 16  0  0  0  0  0  0  0  0          0
21070990 53015010 73 215  4 75 29100 20 0   01  4 53130145236188213   14  2 19  1  0 16 11 23  0  0  0  1  1  0  0  0          3
```

Appendix D: Exporting Data Files

Data files used by and created by the FIRES program can be exported to a data base management system for additional analysis.

The FIRES distribution disk contains three *.STR files that contain DBASE structure definition files that will create an empty DBASE file.

ANA_STRU.STR: Standard Analysis File Structures

PSF_STRU.STR: Standard Passing (Index) File Structures

FPL_STRU.STR: Standard NFMAS FPL Fire Occurrence File Structures

You may use these files to create DBASE files, with structures that allow you to directly import various FIRES files. For example, to create a DBASE file and load a FIRES analysis file (*.ANA), from within your DBASE program type and enter the following commands:

```
CREATE my_file FROM ANA_STRU.STR
APPEND FROM my_file.ana TYPE SDF
```

where my_file and my_file.ana are the filenames you create and import data from, and the capitalized words are DBASE commands.

This creates and loads data into a DBASE file with the field variables as defined in table C-3. To view the DBASE structure of the file, type and enter the command:

```
DISPLAY STRUCTURE
```

You can then perform various DBASE tasks on the file, or export a subset of the file to a new analysis file. For example, you could type and enter the command:

```
COPY TO new_file.ana FOR year > 85 TYPE SDF
```

to create a new analysis file that can be read by FIRES. (This is just an example. You could, of course, do the same thing within FIRES by preparing a new analysis file.)

Andrews, Patricia L.; Bradshaw, Larry S. 1997. FIRES: Fire Information Retrieval and Evaluation System—a program for fire danger rating analysis. Gen. Tech. Rep. INT-GTR-367. Ogden, UT; U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 64 p.

A computer program, FIRES: Fire Information Retrieval and Evaluation System, provides methods for evaluating the performance of fire danger rating indexes. The relationship between fire danger indexes and historical fire occurrence and size is examined through logistic regression and percentiles. Historical seasonal trends of fire danger and fire occurrence can be plotted and compared. Methods for defining critical levels of fire danger are provided. The paper includes a review of NFDRS philosophy and application, a description of input and output, and a summary of fire danger rating programs and data bases and their relationship to FIRES.

Keywords: wildfire, fire weather, fire occurrence, wildland fire, fire potential

Software Availability

FIRES software can be obtained from the Forest Service National Fire and Aviation Management (F&AM) Support Helpdesk or it can be downloaded from the Weather Information Management System (WIMS), from the Wildland Fire Assessment System (WFAS) Internet Site, or from the USDI Interior Fire Coordinator Committee Research Initiative site.

Forest Service F&AM

Telephone	(800) 253-5559

WIMS

SFILE	PGRMS
Filename	FIRE_SEN.EXE (Self-Extracting Distribution File)

USDI

HTTP	http://fwspceaa.nifc.r9.fws.gov/~olson/research/research.html

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